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The Journal of the Imperial Department of Agriculture for the West Indies.

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CONTENTS.

WEST INDIAN BULLETIN

VOL XIV.

EFFORTS IN AID OF PEASANT AGRICULTURE IN THE WEST INDIES.

BY FRANCIS WATTS, C.M.G., D.SC., F.I.C., F.C.S.,

Imperial Commissioner of Agriculture for the West Indies.

For many years a good deal of effort has been made in several West Indian Islands to afford assistance to peasant enterprises and to encourage self-help and thrift.

Early amongst these were the Land Settlement Schemes of Carriacou, Grenada and St. Vincent. The efforts in the two former islands are dealt with in detail in the accompanying paper by Messrs. G. G. Auchinleck and G. Whitefield Smith, while the Land Settlement work in St. Vincent was dealt with in the paper by Mr. W. N. Sands in this Bulletin, Vol. XI. p. 194 *et seq.* A very important account of these latter efforts was published by Mr. M. Tatham in a report on the administration of the Roads and Land Settlement Fund, St. Vincent, and published as Colonial Report—Miscellaneous, No. 77 (1911.)

ST. VINCENT LAND SETTLEMENT SCHEME.

As this number of the Bulletin contains a comprehensive statement of the various branches of the Grenada and Carriacou schemes, it may serve a useful purpose to recapitulate briely the

main heads of the St Vincent effort so as to present a connected and concise story of the work in these closely connected colonies.

In St. Vincent, land settlements have been established in the following areas: Cumberland Valley 1,470 acres; Linley Valley 1,571 acres; New Adelphi and Park Hill 1,101 acres; Richmond Hill 285 acres and Clare Valley-Questelles 633 acres (see *West Indian Bulletin*, Vol. XI, p. 194 *et seq.*) —a total area of 5,060 acres acquired for the purpose in 1899.

In 1910, the Government of St. Vincent acquired Union Island, the most southern of the St. Vincent Grenadine group. This island has an area of some 2,067 acres. The land has been laid out and administered under a Land Settlement Scheme similar to, and based on the experience gained in working, the St. Vincent settlements above referred to.

PARLIAMENTARY REPORT ON THE SETTLEMENT SCHEME.

In 1911, Mr. Tatham reported on the St. Vincent scheme as follows: 'It would be difficult to over-estimate the progress which has been made through the efforts of the Agricultural Department. The officers of this Department have not only dealt with questions concerning the best method of growing and handling different crops, but also with those of maintaining the fertility of the lands of the small holdings. Instruction has been freely given in the making of drains to prevent washing; the formation of compost heaps and manure pens; the growing of leguminous and other plants for green-dressing purposes; the utilization of grass and bush as a mulch for permanent crops and arrowroot; the rotation of crops and pasture fallowing. The advice that has been received in these and other matters is producing a class of small holders which is a valuable asset to the agricultural progress of the Colony.

RESULTS OF A PERMANENT AND FAR-REACHING CHARACTER.

'Finally, when we come to consider the degree of success which has been attained in carrying out the object for which the grant was voted by Parliament, and the general effect on the condition of the Colony and its inhabitants, it may be said at once that the time has not yet come when the full benefits of the scheme can be estimated. Although twelve years have elapsed since the passing of the Land Settlement Ordinance, owing to the nature of the system which has been adopted, progress has necessarily been slow. It has needed many years of patient persuasion and education to induce the peasants to realize that it is for the bettering of their condition, and the relief of their wants, that the work has been carried on. They have been long in grasping the fact that when their instalments have been paid the land will belong to them as their own possession. Nevertheless, if progress has been slow the results will, partly for that very reason, be of a permanent and far-reaching character. Had the whole of the grant-in-aid been expended within the course of a year or two, solely on the construction of roads and bridges, though the effect would have been beneficial to trade and communication within the Colony, the root of that evil which was

discovered by the Royal Commissioners in 1897 would not have been touched. As it is, there is to-day in St. Vincent, in the state of formation, a class of peasant proprietors who have either become or are becoming absolute owners of the land; they have the knowledge that every particle of labour which they put into that land will be for their own benefit during the period in which they pay and even after. If they so desire, they are carefully educated in agriculture, and receive free instructions as to the best methods of obtaining the maximum yield which the nature of each particular allotment will allow.

CO-OPERATION AMONGST THE HOLDERS NEEDED.

'The results are justifying this system of proprietorship. The misconception and mistrust which were at first such a serious obstacle to the successful working of the scheme have to a large extent disappeared. It would be idle, however, to pretend that success is already complete. What is most urgently needed at present is a spirit of closer union and co-operation among the allottees. The institution of the Government cotton factory, already referred to, has been a step in the right direction, but what is still more essential is that the effort should come from the peasants themselves, and not from without, and there are already indications that this will happen in the future. Some months ago a few of the better class of small holders at Clare Valley-Questelles formed an Agricultural Credit Bank, and rules were drawn up embodying some of the best features of the Raiffeisen system. The Government assisted the inception of the project by a loan of £25 at a rate of 5 per cent. per annum, and it is probable that success will ensue, and that other credit banks on similar principles will be instituted elsewhere. Co-operation is also needed in other directions; the formation of central agencies for the disposal of provisions and stock, profit-sharing schemes for the purchase of cacao, arrowroot, cassava starch, and ground nuts; these and other matters of a like nature are further developments on which the success of the Land Settlement Scheme will depend in the future.

ECONOMIC CHANGES BROUGHT ABOUT.

'That the material welfare of the Colony, as a whole, has improved since the year 1897 is a fact about which there is no room for doubt, and there is every indication that the march of progress will continue. How much of this increased prosperity is due to the Land Settlement Scheme is a question to which it would be impossible to give a definite answer. But this much at least can be asserted with confidence: the condition of the native population has emerged from that extremely critical state which the Royal Commissioners found to exist when they visited the island in 1897. Since the decay of the sugar industry, private enterprise has, it is true, established other industries on a sufficiently large scale to afford employment to a great number of the native population. At the same time the existence of a class of peasant proprietors must necessarily have a beneficial effect both on those who have taken advantage of the scheme, and also on the general welfare of the island. Land which formerly was ill-cultivated, or not cultivated at all, is now yielding a rich

return, and certain estates round the coast which before lay almost fallow in the hands of private owners have been bought by the State and resold to an agricultural class. It would be impossible to compare the condition of St. Vincent to-day, with that of twelve years ago without a sincere feeling of gratitude for the much needed assistance which the Parliamentary grant has given, not only to those whose condition it was primarily meant to benefit, but also to the progress aud prosperity of the Colony as a whole.'

Since the report from which these extracts have been taken, was written, there has been steady progress and sensible advance towards further success.

OFFICIAL GUIDANCE AND ADVICE.

The paper by Mr. W. N. Sands which appears in this number of the Bulletin indicates the manner in which useful and successful systems of agriculture suited to the conditions both of the people and of the land they occupy have been evolved under the guidance of officers of the Agricultural Department. The assistance of agricultural officers has been afforded to the peasantry in a quiet unobtrusive manner so to win the confidence of the peasantry and lead them to look upon these officers as friendly advisers having no ulterior objects. Those who have worked amongst the West Indian peasantry know well how difficult it is to gain their confidence, and to receive their following whole heartedly on the advice given by officers of the Government. It may be pointed out that the principle has been carefully adhered to, that officers of Agricultural Departments to whom the peasants are to look for advice and guidance are never made the agents of the Government in matters that may involve the enforcement of penalties. For example, the cotton inspectors, under the Cotton Protection Ordinance, charged with the duty of compelling the destruction of 'old cotton' and of taking proceedings against offenders, are not officers of the Agricultural Department.

NECESSITY FOR BENEVOLENT CONTROL.

In connexion with schemes of land settlement such as have been introduced into Grenada, Carriacou, St. Vincent, and Union Island, it is of fundamental importance for the Government to maintain a benevolent hold over the settlers for a number of years, during which time, through such agencies as agricultural officers and peasant instructors, they can be trained to manage their holdings in a remunerative manner, and may acquire settled agricultural habits. It is essential, too, to maintain this hold so as to prevent the land being pledged for debt or alienated from the settler to whom it has been allotted. The settler should be precluded from disposing of the holding for a considerable number of years, and he should only be permitted to remain on and ultimately acquire it on the clear understanding that he works it fairly and intelligently, and reasonably follows the advice given by agricultural officers.

THE ST. VINCENT CO-OPERATIVE COTTON FACTORY.

The system under which the Government purchases peasant cotton and deals with it on a profit-sharing basis must be regarded as an important measure of affording assistance to peasant land holders. The system which was instituted in 1910 has now been in operation for four seasons and may be regarded as highly successful.

The cotton is graded and purchased by the ginnery at a price depending upon and varying with the market price of cotton. The cotton is ginned, baled and sold by the ginnery, the cost of these operations being deducted from the proceeds; the gross profits being thus ascertained, one-fifth is retained by the ginnery and four-fifths are distributed by way of a bonus to the peasants from whom the cotton was purchased.

Several good features result from this method of working. The peasants are inspired with confidence and carry on their cotton cultivation with a feeling of security in respect to marketing a crop which presents no small difficulty in this connexion. They receive an immediate payment on account for their produce which enables them to carry on their work, while at the close of the season they receive in a lump sum such an amount as may arise by way of bonus, and this sum, in its entirety, is of sufficient importance to be devoted to purposes of improving their property or holdings, or of being employed in some definite and useful manner; whereas had the amount been received in small sums added to the payments on delivery of the cotton, they would more readily be dissipated without producing much benefit. The system has other and important advantages in that it consolidates the peasant-grown cotton and permits of it being graded and marketed in lots of considerable size—a matter appreciated by the buyers who look with disfavour on small and irregularly graded lots.

AGRICULTURAL CREDIT SYSTEMS WANTED.

Brief reference has already been made to the subject of co-operative banks. In all attempts to develop peasant agriculture a point is soon arrived at when the question of finding small sums to enable peasants to carry on their industry forces itself into notice. In order to deal with this, several efforts have been made in St. Vincent. A small Agricultural Loan Bank was started in and has since been successfully operated; but it was found that this still left much to be provided for. Accordingly efforts were made to establish Agricultural Credit Societies on the Raiffeisen system, and two such societies were successfully inaugurated. It was seen that this system could be successfully employed in St. Vincent if some arrangement could be made whereby the societies to be formed could obtain the small sums each requires. Personal individual effort could not be expected to extend very far in the Colony, and the smallness of the several transactions operated as a deterrent in invoking the aid of banks or larger financial agencies.

THE NEW AGRICULTURAL CREDIT ORDINANCE.

After much effort, an Ordinance was finally adopted by the Government whereby loans can be made to properly accredited

societies. This Ordinance appears to embody principles of very considerable importance to more than one West Indian Colony It is therefore reproduced in this number of the Bulletin together with the regulations for the formation and management of Agricultural Credit Societies, and the advice tendered by the Administrator to those who desire to form such societies.

As the Ordinance has only just come into operation it is not possible yet to say anything as to its success; the progress of events connected with it will be watched with great interest.

COMMENCEMENT ON A SMALL SCALE NECESSARY.

It is of fundamental importance to realize that any effort to establish an Agricultural Credit Society on the Raiffeisen principle must be made on a very small scale, so small indeed as almost to invite derision : this constitutes both a source of strength and of weakness; of strength because it limits the liability of any individual who may be willing to assist the scheme to such a point as to remove his fears of serious loss : of weakness in that the whole effort is so small as to fail to enlist the support and sympathy of either the Government or important financial bodies. Nevertheless it may be accepted that in the formation of pioneer Agricultural Credit Societies in West Indian communities, the sum of money to be considered in the formation of each society will be in the nature of from £25 to £50

An account of the agricultural credit movement in the West Indies generally, together with a summary of what has been achieved in India and in other tropical countries, is presented in a paper by Mr. Dunlop in this number of the *West Indian Bulletin.*

LAND SETTLEMENT IN ST. LUCIA.

Stimulated by the success in the other islands of the Windward group of the measure above referred to, it has been decided to take action in St. Lucia, and already a small amount of land has been acquired for a Land Settlement Scheme there.

A further and interesting effort is being made in St. Lucia by the establishment of a small lime factory worked on cooperative lines. It is expected that this factory will be in operation before this is in print. In its business operations very similar methods will be adopted to those employed in dealing with peasant's cotton in the St. Vincent Cotton Ginnery : limes and lime juice will be purchased on a profit-sharing basis, an immediate payment being made when the material is delivered and a bonus paid at the close of the season in the event of the success of the season's working warranting this.

It is anticipated that the factory should prove useful in enabling small cultivators of limes to dispose of their crops in the early stages of the development of their properties, thus relieving them of any anxiety in regard to the provision of machinery and buildings until the magnitude of their transactions warrants their procuring them.

In addition to this, a small factory will prove useful by affording means for demonstrating the kind of machinery

required and the method of dealing with lime products—a matter of some importance in a country where the lime industry is only just being introduced.

In order to initiate the formation of Agricultural Credit Societies, a small society of this kind has been founded in the Soufrière district through the kind co-operation of a local land owner and the Imperial Department of Agriculture. Should this venture prove successful it is hoped that the provisions of an Ordinance on the lines of the one operative in St. Vincent may be extended to St. Lucia.

PEASANT AID IN ANTIGUA : CENTRAL FACTORIES.

In Antigua, encouragement was given to peasant cultivators in connexion with the movement, resulting in the establishment of the Gunthorpes central sugar factory and the enlargement of Bendals sugar factory. Each of these factories entered into an agreement to purchase peasants' canes on the basis of the value at Antigua of 4½ lb. of sugar (96° refiners' crystals) per 100 lb. of canes delivered. It was further agreed that the price to be paid should never be below 7*s.* 6*d.* per ton of canes, even if the value of the equivalent amount of sugar fell below this sum.

On the part of Bendals factory it was agreed that during a period of twenty years, from 1903, the factory should be prepared to purchase, if tendered, 1,500 tons of peasants' canes on the above terms ; the factory could, however, be relieved from its obligation before the expiration of twenty years when it had purchased in the aggregate, under these conditions, a total quantity of 22,500 tons of canes. It is understood that this quantity has been purchased but the buying of peasants' canes on the contract basis still continues. Similarly on the part of Gunthorpes factory it was agreed that during a period of fifteen years the factory should purchase, if tendered, 4,500 tons of peasants' canes on the foregoing terms, the factory to be relieved from its obligation so soon as 75,000 tons of cane had been so purchased. In the first eight seasons, 1905-12, Gunthorpes factory purchased 20,764 tons of peasants' canes under the agreement. It is to be observed that the last few years have been years of drought and short crops, so that the peasants have had great difficulty in growing their canes and the output has been small.

In order to facilitate the growing of canes and other crops by the peasantry, the Government of Antigua reserved for peasants and rented on easy terms a considerable acreage on the properties known as Clare Hall and Skerrets. This may be regarded as a modified form of peasant settlement, though under the conditions of holding, the renter does not ultimately become the owner of the land.

THE VILLAGE SCHEME IN ANTIGUA.

A movement to ameliorate the peasants' conditions that has just been started at Antigua may be briefly alluded to here. This consists in the creation of a new village at Clare Hall, in connexion with which an area has been laid out in lots of 100 feet by 50 feet upon some of which the Government is building cottages to be acquired by the holder on a rent purchase system.

Some lots will be disposed of without cottages on the understanding that within six months of their acquirement the purchaser shall erect a suitable cottage on each, failing which the land will revert to the Government. Tenders are invited for each lot, including those on which cottages are erected as well as those without buildings; an upset price is placed on each and tenders are required to state the amounts they offer over and above this.

Three classes of land are contemplated under this scheme. On land of the 1st Class the purchaser must rent a cottage having a value of not less than £40; on land of the 2nd Class of the value of £25, and on land of the 3rd Class of the value of £15.

In the case of lots on which cottages are erected by the Government, the upset price of the several lots and cottages in the case of lots of the three classes are 1st. Class £35, 2nd. Class £25, 3rd. Class £15. Twenty-five per cent. of the upset price is to be paid at the time of purchase and the remainder in monthly instalments spread over a period of seven years.

No more than one-half of this area of any lot may be covered by buildings and no building intended for human habitation shall be erected within 50 feet of the back boundary of a lot.

Rules are laid down for the management of the affairs of the village, and a Warden is appointed to exercise general supervision.

ANGUILLA: CO-OPERATIVE SALE OF COTTON.

A not inconsiderable scheme for the assistance of the small landowners has been in operation for many years in this island. The assistance referred to is rendered by Mr. Carter Rey, who, aided by the local Government, and by the British Cotton Growing Association, advances small sums to peasant cotton growers, and deals with their cotton crops on a profit-sharing basis: this has had the effect of establishing in Anguilla a peasant cotton industry that has been and continues to be of very great advantage to this small island whose inhabitants, prior to the introduction of cotton growing were frequently reduced to serious straits from drought and want of employment. The work done by Mr. Rey is deserving of high commendation.

GOVERNMENT SCHEMES OF LAND SETTLEMENT IN GRENADA AND THE GRENADINES.

BY GILBERT AUCHINLECK, B.Sc., F.C.S.,
Superintendent of Agriculture, Grenada;

G. WHITFIELD SMITH, F.L.S.,
Commissioner of Carriacou;

AND

WALTER BERTRAND,
Land Officer, Grenada.

Since 1895, the Governments of the Windward Islands have given much attention to the question of land settlement, and few years have passed without the inception of new schemes or considerable additions to the existing ones. St. Vincent appears to have been the first island of the group to undertake a definite scheme, and as early as 1885, in connexion with the survey of the Crown Lands boundary, an attempt was made to form inland settlements for the local peasantry. This, however, was affected by the disastrous hurricane of 1898, and in 1899 the policy was continued by the purchase of two estates in the neighbourhood of the capital. In 1903, Carriacou followed by purchasing Harvey Vale and Beausejour estates, and in 1910 Grenada began on a modest scale. In 1911 Union Island was purchased by the St. Vincent Government and opened up for settlement under the supervision of the Commissioner of Carriacou. In the present year (1913), St. Lucia appears to have definitely entered upon a policy of peasant settlement.

This paper will be confined entirely to a discussion and description of the settlements in Grenada, Carriacou and Union Island, as the writers have not been connected with the St. Vincent and St. Lucia schemes. It is of interest to note however, that in all of the islands mentioned, the Agricultural Departments have in later years been connected with the work of supervision of the settlements, excepting in the case of Carriacou. By its nature an agricultural department is highly suited to this work, as its officers are in a position to give advice in agricultural matters after the initial work of survey has been completed. This is of special importance where, as is frequently the case, a proportion of the settlers have previously followed some trade other than agriculture, or where the settlers have neither the means nor the training necessary for carrying on trials and experiments with new crops.

As will be realized from the information given in this paper, the satisfactory progress made by the settlements formed in the past ten years, and their effects on economic conditions generally, have demonstrated beyond doubt the value of the policy, and it seems quite probable that for some years to come we may look forward to considerable extensions of the existing schemes.

Nature of The Settlements.

In Grenada, Carriacou and Union Island the land settlements have been established entirely for the local peasantry, and they differ from the larger attempts to induce European settlers, which are in progress in Dominica, Tobago, and St. Lucia. They have arisen as a necessary result of certain purely local and internal questions such as scarcity of labour, lessened production of food crops, the absorption of land by larger owners, and the increase of crime traceable to the existence of an unemployed surplus of population. Proximity to the larger trade centres of Trinidad and the Spanish Main has played its part in producing a class of thrifty labourers who return to their island homes with snug little fortunes for investment. Underlying the whole policy is the feeling that, up to a certain point, subdivision of each island among many owners makes more for the general progress, than does monopoly of land by a few large proprietors, and a valuable feature is that it ensures an efficient control by the Government of economic questions generally. This is of special importance in small places where social organization is not high, and where the use of capital and co-operation is little understood; and therefore, in all cases a considerable measure of guidance and help is meted out by the Government to the settlers.

These peasant settlements may therefore be regarded more in the light of remedies for harmful conditions which have grown up in well-populated places than as attempts to settle unopened districts, and, with the sole exception of Morne Rouge North estate in Grenada, the lands have had to be acquired from larger owners specially for the purpose of settlement. In one case in Carriacou expropriation by the Government was resorted to in order to compel the sale of lands held by proprietors who made little or no use of them. Union Island, and in Carriacou the estates of Beausejour, Harvey Vale and Mt. Pleasant; in Grenada Westerhall, Morne Rouge South and Calivigny Annex were all acquired by purchase from private owners.

It has not been the policy of the Governments to seek for large profits from the sale of settlement lands, and all that is required is that the purchase price or original value be recovered, together with survey and other expenses and the interest usually earned by other Government investments. In certain cases, notably in Carriacou, very considerable profits have accrued; but these are quite exceptional and due to unforeseen circumstances. The terms upon which the lots are sold are liberal in the extreme, a maximum of twelve years being allowed each settler for payment, and he is given several options as to the methods of payment: he may pay the whole cost in advance, in which case he escapes payment of interest; or he may deposit 25 per cent. of the purchase money in advance, for the next three years pay nothing but interest on the outstanding balance, and then complete his purchase by nine annual instalments. In order to obtain a reputable class of settlers, the course is usually followed, in cases when several applications are received for one lot, of giving priority to those who can pay the whole purchase money in

advance, and next to those who are prepared to pay 25 per cent. down. Further provision is made for poorer settlers by an arrangement allowing purchases to be made by twelve equal annual instalments. Full details of the system of sale may be found in the copy of the rules reprinted at the end of this paper, so that there is little need for dwelling on the matter here, but we might mention that a statement is exacted from each purchaser that he owns no other land, and it is also usually found advisable not to sell several lots to one family: the reasons for these restrictions will be readily understood.

An important feature of the rules is that, whatever the system of payment be, no settler is allowed to sell, transfer or mortgage his allotment during the period of twelve years from the date of his first occupation, without special permission from the Governor. The effect of this clause is apparent in Carriacou and is gradually being manifested in Grenada: there always has been a tendency on the part of well-to-do peasant owners to mortgage their lands, and with the exorbitant rate of interest charged by the money lenders, these transactions end usually in disaster. It seems likely that in many cases where settlers are in urgent need of money to work and manure their lands, some system of advances by the Government will have to be adopted, and in the course of time, useful little agricultural banks should spring into being on the settlements. At present the settlers are prohibited from raising loans on the security of their holdings, and in a good many cases there seems to be need for cash purchases of manures, good seed, etc. No doubt an efficient system of advances in special cases could be devised and carried out through the agricultural departments.

The cost of starting a settlement naturally varies considerably, being influenced by situation, accessibility, demand for land and a host of other factors. The items which affect the final selling price of lots, and which must be taken into account, may be classified as follows:—

(1) Cost or value of the land.

(2) Expenses of survey.

(3) Roads.

(4) Value of Government reserves such as forests, water source, and experiment plots.

(5) Interest on the capital invested.

(6) Capitalization of necessary enterprises, such as cotton or sugar factories, granaries, residential cottages, importation of agricultural supplies, seeds, etc., water-supply, drainage, etc.

Very often such work as drainage, provision of water-supply, roads, forest reserves, etc., are of distinct enough advantage to neighbouring districts to warrant its cost being paid for from funds other than those set aside for settlement purposes, and a much lower selling rate per lot can therefore be fixed. In any event the traffic from a prosperous settlement will usually justify the charging of road upkeep to ordinary public funds. The selling price per acre of the settlements, therefore, varies considerably, but in all cases it must be kept within the purchasing capacity of the peasantry. In the settlements dealt with here,

prices varying from £2 to £15 per acre have readily been paid by settlers—a fact that can be understood when we remember that the normal rental value of the same quality of land is 20s. per acre per annum, in the islands concerned, so that settlers purchase land by payment of instalments often less than the rental value of other land. There seems little doubt that comparatively large areas, if suitable for the more valuable permanent crops, such as cacao and limes, could be sold at the rate of £20 to £25 per acre.

Aims and Effects.

There has always been a misapprehension on the part of the public as to the effect of a policy of land settlement on the labour supply. There seems little doubt that labour will be made more expensive, the increase in the cost being up to a certain point proportional to the size of the lots sold and the consequent measure of independence gained by the peasantry. In the case of Carriacou, where the ratio of the area of land purchased by settlers to the total area of the island is $\frac{2000}{8800}$ or 1 : 4¼, the labour supply appears to have increased, and the writers have seen in 1911 one large owner employing a staff of over 200 labourers, this, where we may safely state that there has been no immigration of settlers from other islands. One of the Grenada settlements, Morne Rouge, is situated in a district in which the labour supply has hitherto been uncertain and insufficient for the demands of neighbouring estates, and already three years after the opening of the settlement there is a slight improvement in the quality and quantity of the labour.

A curious and unexpected feature of these settlements has been that up to the present it has been practically impossible to draw settlers from districts as far as, say, 10 miles from the site of the settlements. It had been naturally supposed that labourers from the more congested districts of the island would have been drawn to the settlements, and for this reason it was regarded as an advantage that each settlement should be in a comparatively sparsely populated district, but the expectation has not been fulfilled, and we can only conclude that the average peasant in Grenada prefers a precarious living in his own parish to a better one in another district. The increase of labour supply consequent on the establishment of the settlements must therefore be attributed to some cause other than the removal of labour at the expense of the more thickly peopled districts.

The fact is, that the improvement of the quality of labour may be explained by the realization of a very human trait: a peasant barely subsisting on low labour wages will always be shiftless, unreliable and disinclined to work, but the instant he becomes a land owner and is able to provide himself with good food and comfortable living he seeks labour in order to obtain money for further luxuries. At the same time his absolute dependence on the larger owners is, of course, greatly lessened, but it has not been found in the past that such absolute dependence leads to any ultimate benefit, either to the larger owners or to the community as a whole. The general effect of a peasant settlement on labour supply may then be summed up by saying that labour is improved in quality and quantity *because* the peas-

antry are more independent—a fact which is by no means peculiar to the West Indies.

It is easier to realize the beneficial effects of the land settlements than it is to define them. The section of this paper dealing with the Carriacou scheme enters fully into the question of the lessening of offences and crimes in that island, which has followed upon the initiation of the policy, particularly offences which may be expected to arise out of shiftlessness and want of occupation, such as petty theft, smuggling, trespass, etc., and it can be readily understood that such an effect is more readily gauged in Carriacou than in Grenada, in which latter place the area of the settlements is negligible when compared with that of other estates.

The total effect of the settlements may, perhaps, be summed up by stating that they afforded to the Government an efficient means of controlling almost every department of work, and that without any measures of compulsion. Population has rapidly increased in Carriacou, trade both local and foreign sprung up, crime has lessened, labour supply has improved, it has rendered more easy the introduction of better agricultural methods, and it does not need much thought to realize that with increasing prosperity the general enlightenment and education of the lower classes will improve considerably. These benefits are of especial importance in a place where the lower classes have neither the means nor education to handle their own affairs efficiently.

The Grenada Settlements.

The Grenada Land Settlement Scheme was started in 1909, when a sum of £5,000 was set aside from the surplus funds of the Colony to be utilized for the purchase of suitable lands. The Hon. Edward Drayton, C.M.G., Colonial Secretary, who had been in the past connected with the St. Vincent Scheme, and who had initiated and controlled the very successful scheme in Carriacou, has been in control of the Grenada scheme since its inception. To his guidance, therefore, we must attribute a measure of the success which has attended this scheme, which largely through ignorance of its aim and effects was at first looked upon with some suspicion by local planters.

The settlements at the date of writing (1913) comprise the estates of Morne Rouge North, Morne Rouge South, Westerhall and Calivigny Annex, and following are the statistics concerning them :—

Settlement.	Area.	Number of lots.	Total selling price.	Average area of lots.	Average price per acre.
	a. r. p.		£ s. d.	a. r. p.	£ s. d.
Morne Rouge North	95 2 2	36	249 2 3	2 2 24	2 12 0
„ „ South	87 2 33	27	394 19 5	3 0 39	4 10 9
Westerhall	...295 3 9	104	1,697 17 6	2 3 15	5 14 0
Calivigny Annex ...	58 3 25	23	431 10 2	2 2 9	7 6 5
Totals	...537 3 29	190	2,773 9 4	2 3 1	5 3 1

The present financial position of the scheme is as follows:—

	No. of lots sold.	Receipts at 31.8.13.	
		£ s. d.	
Morne Rouge North	25	49 8 10	
Morne Rouge South	19	76 11 8	
Westerhall	84	295 3 8 =	£421 4 2
	128		

There have been no sales at Calivigny as the valuations of the lots have not yet been approved by the Government. The whole of the land originally offered for sale at Morne Rouge was taken up by peasants several months ago, but small additional areas have been added in the past few months and are now on sale: these comprise a few lots on a plateau at the top of the Morne Rouge hills and a few in the southern section.

At Morne Rouge South, Morne Rouge North and Westerhall there are small reserves held by the Government for administration purposes, part of each being used for agricultural experiments under the control of the Agricultural Department. On each reserve a house has been placed by the Government, part of which is occupied by a resident ranger in the case of Westerhall. The effect of these plots, which serve as centres for good experiment work by the Department, as well as for control has been very beneficial.

MORNE ROUGE.

This settlement comprises two sections, North and South, one of which was the property of the Government before the scheme was started in Grenada, and the major portion of the other purchased from the contiguous estate known as 'True Blue'. The two sections are separated by a low range of hills, most of which has been set aside as a wood reserve, but the top of which is level and cleared and has now been surveyed into half a dozen lots for sale. The estate is situated about 4 miles by land from St. George's the capital of the island, but is distant by sea only about 2 miles, and is therefore well placed for supplying the town with fruits and vegetables.

Both sections contain small fertile valleys, the soil of which is uniformly black or dark-grey, composed of volcanic ash and washings from the hills, and therefore of a heavy clayey texture. For years past the land had been lying fallow under a growth of Acacia, logwood and other hardy leguminous scrub, and with proper handling should therefore yield good crops for several years to come, although the natural fertility is seriously handicapped by the annual drought which lasts from January to May, the rainfall of the district being in the neighbourhood of 40 inches per annum. Owing to the formation of the hills and also the proximity to the sea, it was possible to make fair provision for water-supply by sinking wells, three of which are now in operation on the northern, and one on the southern section: This water when examined in 1911 in the Department Laboratory was found to have the following composition :—

Total solids per million	900·0
Hardness degrees per gallon	16·8

A physical analysis of the valley soil from the northern section gave the following results :—

Stones	Nil.	
Coarse gravel	1·4	per cent.
Gravel	4·5	„
Coarse sand	2·7	„
Medium sand	2·0	„
Fine sand	11·5	„
Very fine sand	9·0	„
Silt	13·2	„
Fine silt	22·4	„
Clay	16·2	„
Organic matter and Combined matter	9·5	„
Water at 100°C.	7·6	„
	100·0	

The soil is suited for cultivation of tobacco, Indian corn, sugar-cane, vegetables and hardier types of fruit. Coarser grades of tobacco have been grown with considerable success by one settler in the north and made up into low grade cigars which sold readily in the local market. Indian corn grows rapidly and well, and particularly in the first year of cultivation gave excellent yields. In the sandy lands near to the sea a better quality of sweet potato is grown than in any other part of the island, while yams, tannias and bananas flourish in the valley soil.

In 1910, 1911, 1912 and 1913 trials have been made by the Agricultural Department with cotton, Marie Galante, Sea Island, Mitaffi and Abassi types having been tried, the results in all cases being exceedingly bad: owing to the heavy soil the bolls are persistently attacked before maturity and destroyed by a bacterial disease, and in consequence there seems little chance of building up an industry in this crop, at any rate for some years, or until an immune type is discovered or bred. Limes thrive in the district and a small plot set out in 1910 by the Agricultural Department has this year reached the fruiting stage: there seems

little reason to doubt that a profitable lime juice industry could be developed in the next few years, although the fruit owing to its small size could hardly be profitably shipped green.

Sugar-cane will probably be the staple crop for some years to come, and the tendency on the part of the settlers now is to utilize the whole of their land for this crop to the exclusion of others. In 1912 several thousands of plants of variety B.147 were distributed to the settlers, and the type has proved itself hardy and excellent for ratooning.

In March 1913, the following areas were cultivated in various crops :—

	Morne Rouge North.	Morne Rouge South.
Sugar-cane	20 acres	15 acres
Cotton	3 „	nil
Tobacco	½-acre	nil
Ground provisions and corn	35 acres	25 acres
Coco-nuts	160 trees	10 trees

An interesting analysis was made in March 1913 of the classes of peasants who had become settlers in the previous two years. It will be seen that agricultural labourers predominate, although other occupations are fairly well represented :—

	Morne Rouge N.	Morne Rouge S.	Westerhall.
Women	5	3	9
Agricultural labourers ...	12	12	40
Carpenters	2	1	6
Masons	1	0	5
Shopkeepers	1	1	...
Ex-schoolmasters ...	1	...	...
Other trades	1	...	4
	23	17	64—10

A considerable amount of help has been given to the settlers and several improvements and facilities carried out by the Government in the past few years at Morne Rouge. In 1914 a small sugar-factory was erected, with a nominal capacity of $\frac{1}{2}$-ton of sugar per day, the cost being approximately £300. In 1913 this mill was rented by a settler and the standing cane crop ground and boiled. It appears probable that to avoid jealousy the plan will have to be followed in future of charging a rental per day for the factory and allowing each settler to handle his own crop, due provision being made to ensure careful treatment of the engine and the sugar batteries. The mill is of $5\frac{1}{2}$ h. p. made by Death and Ellwood of England, and the oil engine 7 h. p. made by Crossley, and the battery is composed of four tayches ranging from 150 to 70 gallons in capacity: a concrete tank for sugar storage and a couple of 'coolers' complete the equipment.

An experiment plot, 4 acres in area, was laid down at Morne Rouge South by the Agricultural Department in 1910, to be used for trials of new economic crops and for growing supplies for distribution. The crops under experiment this year are coco-nuts ($\frac{1}{2}$-acre), limes ($\frac{1}{2}$-acre), sugar-cane ($\frac{1}{2}$-acre, six varieties), guavas (1 acre), chillies (1 acre), potatoes, yams, manioc, cotton and corn. So far, separate reports have been issued on the corn and cotton trials, and one will soon appear on the lime experiments. Minor trials with pigeon peas, sorrel, woolly pyrol and cowpeas have been made and the seed sold or distributed to the settlers.

In 1912 prizes were offered for the best cane and corn crops on these settlements by the Agricultural and Commercial Society, and there seems good reason to believe that such competitions will be productive of most beneficial results.

WESTERHALL AND CALIVIGNY.

This settlement is situated on the southern coast and comprises four extensive valleys with low ridges intervening. The Westerhall section was purchased in 1911 and opened for sale in 1912, and Calivigny added by purchase in 1912. This latter annex has a frontage on the sea, in a well protected bay, and there seems no reason against the development of a flourishing little fishing trade in future years.

At the date of purchase the district was practically unopened and the first act of the Government was to set aside £100 for laying down a good system of roads. A cart road about 1 mile long connecting the main south coast road with the St. George-Grenville main road and running through the settlement has now been constructed, and in addition about 3 miles of path have been laid down to give access from this road to the various lots. The larger road not only serves for the settlers, but has had the effect of opening up the district for general traffic, and has now become practically a part of the system of public roads of the Colony. A system of roads has also now been planned by the Land Officer for Calivigny, which when completed will form a useful extension of the Westerhall system. The whole settlement is now patrolled by a resident ranger under the Land

Officer, and a good building has been erected to serve the double purpose of housing the ranger and providing rest-room quarters for Department Officers when they visit the settlement.

The soil of the settlement is typical of those which compose the coastal belt of Grenada. being underlaid entirely by compacted strata of volcanic gravel and coarse sand which give rise to a grey, rather open soil. The strata, known locally as 'tiff', are exceedingly porous, and in consequence the soil retains very little water and suffers more severely during drought than the rainfall of the district (50 to 60 inches) would lead one to imagine. Except in the valleys, the surface soil is exceedingly shallow and for years past has supported a vegetation composed of hardy 'scrub'. The consistency of the strata is such as to induce the belief that they may in the course of years become broken up by cultivation and the soil gradually deepened.

There has not been time enough to obtain very definite information as to the crops most suitable for this district. The experiment plot of 7 acres which was established in 1912 in the neighbourhood of the rest-room is at present being cultivated in sugar-cane, limes, cotton, corn, manioc, pine-apples, coco-nuts, bananas and potatoes. Mulberries are also being tried in the hope of later inducing some of the settlers to start a small silk industry. Sesame, known locally as 'jidgeree', appears to grow well and might later be developed into a small local industry: the seed is much used locally in cakes and the type grown appears to be thoroughly acclimatized and free from the diseases which attack it elsewhere. The cotton trials have resulted in failure, as at Morne Rouge, through the attacks of a bacterial boll disease. Coco-nuts have given, so far, much better results than were expected in view of the severity of the annual droughts.

There seems little doubt, on the whole, that on this settlement, as at Morne Rouge, sugar-cane will be the staple crop for many years to come. There are two muscovado estates in the neighbourhood, and in addition three peasants intend setting up small mills, worked by animal power, on their lots to produce the undrained crude sugar known locally as 'wet' sugar: the yield is low and there is much room for improvement in methods of cultivation, as is evidenced by a test case made by the Department in which $\frac{1}{4}$-acre of plant canes yielded 770lb. of cane, or $1\frac{1}{4}$ tons per acre.

The Carriacou Settlements.

A brief description of this interesting dependency and the cause which led up to the formation of a scheme which in the short space of ten years has brought the island from a condition of pauperism and destitution to one of comparative affluence may not be without interest.

Carriacou lies about 20 miles to the North of Grenada in 12° 29″ North Latitude and 61° 15″ Longitude West of Greenwich. It contains approximately 8,466 acres or about 13 square miles. That this island, up to comparatively recent times, was the abode of a wealthy and flourishing community of sugar and cotton planters, the numerous ruins of large, and what must

have been, powerfully equipped steam sugar factories, bear ample testimony, owing to what may be termed, unaccountable barrenness of records, both in Grenada and St. Vincent, as to what took place in the past in this flourishing dependency, it is not possible to ascertain with certainty the extent of the industries at that time but that considerable prosperity must have been attained may be inferred from the fact that in the year 1823 the exports from this island were as follows:

Cotton	384,676 lb.	1,282 bales
Sugar	2,063 640 ..	1,000 hhds.
Molasses	137,319 galls.	1,370 puncheons
Rum	14,742 ..	245 hhds.

From the foregoing, it may also be reasonably inferred, that the labouring population must always have been considerable and that from force of circumstances and the absence of land for squatting was compelled to habits of industry and thrift—traits which have fortunately been handed down to the present day, and especially characterize the Carriacou peasant.

For the reason already given it is not possible also to assign the cause why these fine estates were abandoned by their owners in England: but it would seem that this policy of 'scuttle' must have taken place not so long ago, as we find that as recently as the year 1870, before the sugar question became acute, two at least of these estates were in efficient working order.

Following their abandonment the dark days of the island commenced. Buildings rapidly went to ruin, the estates passed into the hands of impecunious lessees, and money in the shape of wages ceased to be circulated among the labouring classes a total extinction of the sugar industry naturally followed, and such cultivation as survived namely, that of cotton, corn, and peas was conducted on the crudest system of 'Metayerage,' by a peasantry who were forced to labour or starve. Under such conditions, affairs steadily drifted from bad to worse, until the inhabitants were reduced to a deplorable state of destitution and pauperism and were the cause of much concern to the Government of the Colony.

It was at this stage, owing to the untiring efforts of the Hon. Edward Drayton, C.M.G., on behalf of the people, that the idea of establishing a peasant proprietary settlement took definite shape.

Based on an intimate knowledge of the needs of the little dependency, his scheme met with the favourable support of the Governor, Sir Robert Llewellyn, K.C.M.G., and it having been officially sanctioned by the Secretary of State, it was effectively launched in May of the year 1903, when the Government acquired the Beausejour estate (709 acres), followed rapidly in succeeding years by the purchase of Harvey Ville estate (309 acres), Belair estate (302 acres), North Belle Vue (115 acres), and so recently as

1912, by the acquisition of Mt. Pleasant estate—(488 acres),—or roughly speaking, about 2,000 acres altogether

The last mentioned estate however, has not yet been allotted and does not, therefore come within the scope of this report.

The extent of land actually dealt with so far is 1,510 acres. Of this area 421 acres or slightly over one-fourth have been reserved for forest conservation—the importance of which will be referred to later—leaving about 1,089 acres actually allotted to peasant settlers at the time of writing

Excluding the purchase of the Mt. Pleasant estate already referred to, the entire cost of the scheme up to August 31, 1913, has been £8,419, while receipts from the sale of lands amount to £8,587. Roughly speaking, about £600 still remains unpaid in the hands of allottees, bearing interest at the rate of 5 per cent., and agricultural lots and fourteen house lots valued at £64, are unsold.

The asset valuation of reserves and other property resulting from the acquisition of the estates above referred to, as impound of expenditure, amounted in round numbers to £3,672 made up as follows :—

Buildings and sites	...	...	£1,682 0 0
Reservoirs ...	...	... ..	250 0 0
Reserves, etc.	...	... ...	1,740 0 0
			£3,672 0 0

It may however be mentioned here, that although the realization of capital expended (without profits) forms the basis of the land scheme, the foregoing figures disclose the satisfactory position of this movement from a financial point of view. The uplifting effect however, which it has had on the fortunes and character of the island and its people is even more remarkable and important.

Prior to 1904, as already stated, the condition of the island was deplorable. The town of Hillsborough, itself overgrown with bush, was surrounded by swamps and Acacia scrub.

These areas, once the flourishing cane fields of the Beausejour estate, were given over to fever-breeding mosquitoes, and where-ever the land was cultivated by metayers, it was done in the half-hearted manner which betokened the efforts of a people lost to all hope, who were apathetically content with such feeble returns as could be extracted from a soil in which they had no interest or part beyond that of satisfying immediate needs.

With the advent of the land scheme, a remarkable change took place. Lands were rapidly taken up, cleared and planted. Agricultural lots were fenced in with barbed wire, the Government supplying over 60 coils on easy terms of payment to the Beausejour allottees alone for this purpose.

Even more significant was the development. For years the young and able-bodied male population of the island has been compelled *faute de mieux* to seek a field for their labour in the neighbouring island of Trinidad and the Venezuelan republic, in

which countries they were greatly valued on account of their sober and industrious habits.

Having no means of investing their money at home, the Savings Bank at Trinidad consequently became the repository of quite considerable sums.

Immediately on the inauguration of the land scheme a large portion of these were withdrawn and invested at Carriacou, either in the purchase of land or in the erection of neat and substantial cottages on the holdings of their parents.

The well-kept allotments of these peasants, each with its attractive cottage, affords an object lesson in the possibilities of peasant proprietary settlements, when well conducted, unique in the topography of these islands.

Not less remarkable has been the moral effect on the people themselves Court records disclose that prior to 1903 upwards of 500 cases were brought before the Magistrate of the District for hearing. In 1913, ten years afterwards, this number had dwindled to about 280, chiefly confined to offences of the most trivial description. The fact that perfect law and order are maintained in a country of over 7,000 souls, by four policemen speaks volumes for the law-abiding qualities of the inhabitants.

A copy of the rules governing the Carriacou Land Settlement forms an appendix to this report and gives full and explanatory details on every point connected with the working of the scheme.

One clause of the regulations however, seems especialy worthy of notice. Reference is made to that which provides that no allottee can sell, alienate or mortgage his holdings for a period of twelve years from the date of allotment without the consent of the Governor.

Such a wise provision, it is not too much to say, has proved one of the main features of the success of the scheme.

Peasant holders, like other mortals, are prone in some cases to habits of improvidence. In the neighbourhood of land settlements there usually exists the far seeing—or as some call him the smart -middleman who is always ready to help such beings when in difficulty. Mortgages are readily given under such circumstances, and in a very short while a process of absorption takes place which usually ends in disaster to the borrower. The clause above referred to, by barring the way effectually, for ten years at least, to contingencies of this kind, has compelled the allottee to be self-reliant and to surmount difficulties without recourse to outside assistance.

It has been found at Carriacou that a holding varying in size from 2 to 3 acres is about as much an unaided peasant can handle properly. On larger areas the tendency is for him to become careless and slipshod in his methods of cultivation.

Cotton, corn, peas, ground nuts and vegetables, stock (cattle and sheep), and poultry constitute the products which chiefly engage the attention of allottees in Carriacou. In some instances breadfruit trees and bananas have been planted while others are making good use of sandy areas for the cultivation of coco-nuts.

A description of the land scheme would be incomplete without reference to the beneficial support which the forest reservation, already referred to (121 acres), has had in the rainfall conservation of the island.

Several never-failing springs now exist in the neighbourhood of the foot-hills to the leeward side of the island, and although the windward and more exposed districts will always continue to suffer from scarcity of water during periods of prolonged drought, it is safe to say that the water famines from which the dependency used to suffer so acutely in former years are not likely to recur.

How the increasing prosperity of the island, following rapidly in the wake of the land scheme, has brought about the erection of a reliable steel jetty in Hillsborough Bay, a commodious hospital, telephone service and other adjuncts of a prosperous and progressive community, have been fully dealt with in the Annual Administration Reports of the dependency, and need not be referred to here.

In conclusion however, it may be stated that not a single case has as yet occurred where the allottee has forfeited his land through inability to pay instalments of purchase money and interest.

THE UNION ISLAND SETTLEMENT.

Union Island, another of the Grenadines, lies to the north of Carriacou, from which island it is separated by a narrow channel about 5 miles in width.

Prior to 1910, this island was private property and for many years had been worked as a cotton plantation on the metayer or share system, the conditions of which were even more harassing to the cultivator than those which obtained at Carriacou.

The inhabitants numbering about 1,500, were at that time herded together into two small villages of squalid wattle and daub huts without the least regard for privacy or sanitation. They were not allowed to keep cattle or to grow provisions except in special localities where the soil was sandy and almost worthless for cultivation.

Under such circumstances, it is not surprising that the islanders bore an unenviable reputation for lawlessness among the other inhabitants of these peaceful islands.

In 1910, at the earnest request of the people, the Administrator of St. Vincent, the Hon C. Gideon Murray, with the approval of the Secretary of State, purchased the island, and immediately inaugurated the establishment of a peasant land settlement on the lines so successfully adopted in Carriacou. The island was surveyed, and after setting aside 606 acres for fores conservation, the remainder, about 1.400 acres, was cut up into al lotments varying in size from 2 to 5 acres.

Nearly all the lots have been taken up, and already the exports of cotton, poultry and small stock from the island have been doubled.

Up to March 31, 1913, £7,000, had been expended on this scheme. Two hundred and sixty-six agricultural lots of the value

of £6,410 had been sold and eighty-four lots representing a value of £2,810, remain on hand awaiting purchasers. (Many of these are now being negotiated for.) In addition, an asset valuation of £2,750 has been placed on reserve lands, buildings, and water cisterns.

The land scheme at Union Island differs from that at Carriacou in a few unimportant details which, however, seem worthy of mention in a report of this kind. No interest is charged on outstanding instalments of purchase money, the collection of this being arrived at by including it as a part of the purchase money payable by equal yearly instalments. This innovation has worked very satisfactorily so far, and seems especially suitable to a class of persons by whom the dual payment of instalments and interest is not readily understood.

Another feature of the Union Island scheme, differing from that of Carriacou, is that no alottee is allowed to pay, during any one year, more than the amount of the instalment of purchase money agreed upon for that year. In other respects the regulations governing both land schemes are identical

The product of the soil being the same as Carriacou, call for no remark.

The outlook for the land scheme at Union Island is of the most hopeful character. The squalid villages referred to are fast disappearing, and on all sides one sees neat, and in some cases pretentious structures in course of erection on the lands of allottees.

Several provision shops have sprung into existence and the place now wears an air of prosperity where three short years ago squalor and poverty reigned supreme.

GRENADA.

THE CROWN LANDS ORDINANCE 1896.

Rules made by the Governor-in-Council for the sale of Crown Lands in the Island of Grenada under the authority of the Crown Lands Ordinance 1896.

Gazetted 2nd May, 1910.

1. These rules shall apply to the Crown lands known as Morne Rouge estate situate in the parish of St. George in the Island of Grenada and to such other Crown lands as the Governor may, by order in Council, declare them to be applicable.

2. Crown lands to which these rules apply shall, save as hereinafter provided, be surveyed before any allotment of it is made, and the administration and disposal of such lands and of all details connected therewith shall, subject to these rules and to such orders, as may be given by the Governor, be entrusted to an officer hereinafter styled the 'Land Officer'.

3. The Governor-in-Council may, where circumstances so require, authorize an allotment being made at a provisional valuation, prior to the completion of the survey, which provision a valuation shall, until such allotment shall be valued in accordance with these rules, be deemed to be the value thereof for the purpose of such rules; but thereafter the value so fixed as hereinafter provided shall be deemed to have been and shall be the value thereof for all purposes.

4. In making the survey the following Reserves shall be made:—

(1) All pounds and wells, the beds and banks of rivers and of any important stream or tributary, and a space of half a chain around the source and on either bank thereof:

(2) Swamps, exposed ridges, and such forests as may be deemed necessary for the purpose of Forest Conservation:

(3) Such land, including sites for Churches, Chapels, Schools, or other public purposes, as the Governor-in-Council may approve as necessary or desirable for the general good.:

(4) Such lands as may be necessary for roads or paths to each allotment or group of allotments:

(5) Such land as may be requisite for villages:

(6) Any continuous tract of altogether precipitous or uncultivable land.

5. The remainder of the land shall be divided into allotments of not less than two, and not more than five acres each, and no allotment shall exceed five acres except with the approval of the Governor-in-Council. In surveying the land for allotment the Surveyor shall as far as possible include in one allotment any cultivation of an existing tenant on the land.

6. Each allotment shall be numbered and shall have its number clearly displayed on some part of it.

7. Every corner of each allotment shall be marked by hardwood posts or stone pillars and the general outline by dragon's blood or immortelle plants, which plants shall be carefully tended by the allottee.

8. The Land Officer shall keep a Register in the form approved by the Governor in which shall be recorded in parallel columns—

(*a*) the number, area, and value of each allotment,

(*b*) the name of the allottee,

(*c*) the date of the allotment,

(*d*) the amount paid previous to allotment,

(*e*) the sums paid on account of instalments and the dates of such payments,

(*f*) any other information which the Governor may prescribe.

9. When the survey is complete the Land Officer (assisted by such Assessors, if any, as may be appointed by the Governor,) shall proceed to value each allotment, and shall so apportion the

value of each that the total valuation shall cover the total amount of the expenses incurred by the Government in the purchase of the whole area of land including any legal expenses and costs of survey.

10. The Land Officer shall as soon as possible submit to the Governor a list of the allotments with the value of each. On approval of the valuations by the Governor-in-Council the value of each allotment shall be recorded in the Register.

11. The Land Officer shall then by notice in the Gazette, and by means of Posters, or in any other way he may deem desirable, invite applications in writing, (which must be made on a printed form to be obtained from the Land Officer), for allotments, and on expiration of 14 days from the date of the notice shall proceed subject to the Governor's approval, to allot the same in accordance with the following rules: Provided however that he shall not make an allotment of land to any person who is already an owner of land without the sanction of the Governor.

12. In selecting applicants for allotments priority shall be given firstly to those who are prepared to pay down the whole value of the lots, and secondly to those who are prepared to pay not less than 25 per cent of that value, taken in order of date of application: Provided that an existing tenant shall have the first choice of purchasing the allotment within which his cultivation falls unless the Governor, on the report of the Land Officer, shall decide that such tenant is otherwise ineligible.

13. The remainder of the purchase money of an allotment on which 25 per cent. or more has been paid shall be divided into nine parts, and the allottee shall on the expiration of the third year from the date on which his conditional permit to occupy (which will be the date of the first payment on account) was issued to him by the Land Officer, and thereafter on the same day in each year, for nine consecutive years, pay annually, as an instalment, one of those parts; and shall also so long after the date of the conditional permit as any part of the purchase money remains due, pay interest thereon at the rate of 5 per cent. per annum on the same day in each successive year.

14. When all the applications from persons who are able to pay cash or not less than 25 per cent. of the purchase money have been dealt with, the Governor may in his discretion allot to the applicants, according to the dates of their applications, the remaining lots of land, if such applicants be recommended by the Land Officer, and considered eligible by the Governor.

15. Such persons shall receive from the Land Officer a conditional permit to occupy the allotment in respect of which they have been selected on condition of paying for such allotment one-twelfth part of the purchase money; and at the expiration of one year from the date of such permit and at the same date in each succeeding year, a further one-twelfth part of the purchase money shall be payable together with interest at 5 per cent. per annum on the amount of such purchase money then outstanding.

16. An allottee may at any time pay off any instalment or instalments outstanding. An allottee may at any time pay on account of any instalment any sum not less than four shillings,

provide that there shall be no deduction of interest by reason of any part payment of an instalment.

17. (a) Land reserved for a village under rule 4 shall be called a 'Village Lot' and shall be laid out in house spots not exceeding 60 feet square each, with suitable space reserved for streets and cross streets to afford access to such house spots.

(b) For the purpose of valuation a Village Lot shall be treated as an allotment, and its value fixed as in rule 9 with the addition of all expenses attending its devision into house spots.

(c) The value of each house spot shall be apportioned so that the total valuation shall cover the total amount of the value of the Village Lot.

(d) Every allottee of an allotment shall be entitled to purchase and hold a house spot on the adjacent Village Lot, so long as any remain unsold, on the same conditions as an allotment may be purchased and held.

18. House spots may be sold or leased to persons who are not allottees and special cases dealt with on such terms and conditions as may be approved in each case by the Governor in-Council.

19. The conditions of tenure of allotments shall be as follows:-

(*a*) Every purchaser shall for a period of 12 years reckoning from the date of allotment reside ordinarily in the island of Grenada, commencing to do so six months after obtaining a conditional permit under these regulations unless the Land Officer, with the approval of the Governor, shall otherwise permit.

(*b*) No land may be alienated, let or incumbered, for a period of twelve years from the date of allotment without the consent of the Governor.

The word 'alienated', does not refer to or include an involuntary alienation as in the case of descent or bankruptcy: nor an alienation partly involuntary as in the case of a devise by will.

(*c*) No exclusive right shall vest in any person to any spring, stream, pond, well, or other natural source of water situate in or flowing through any land.

(*d*) The Governor may at any time resume possession of any part or parts of an allotment not exceeding one-tenth of the said allotment, for roads, on paying therefor at the same rate per acre as that at which the allotment was originally sold, and also for the value of such crops as may be on such selected line or road.

(*e*) No cacoa shall be planted on any land for a period of twelve yearsfrom the date of allotment without the consent in writing of the Governor.

(*f*) All instalments and interest shall be punctually paid on or before the day of which they are due.

20. On failure by an allottee of an allotment or house spot to comply with any of the conditions of tenure hereinbefore

detailed, the Land Officer shall immediately report all the facts of the case to the Governor, who shall enquire as fully as possible into all the circumstances of the default, whereupon the Governor-in-Council may order that the right to such allotment of house spot, and all crops, and all instalments paid, and all other rights of the allottee shall be forfeited, without any appeal to any Court, or may make such other order as the circumstances of the case may require.

21. Notice of an order so made shall be served upon the allottee or left at his last known place of abode, and no act of re-entry shall be necessary, and such allotment of house spot shall be at the disposal of the Governor, either to re sell then or at any future time.

22. On payment in full by an allottee of the purchase money of an allotment or house spot he shall be entitled to a grant of the same. Such grant shall be in a form approved by the Governor-in-Council, and shall be recorded in the Land Registry Office free of all cost to the allottee, except stamp duty.

Approved and passed by the Governor-in-Council this 22nd day of April, 1910.

T. T. DYER,
Clerk of Councils.

BIBLIOGRAPHY OF REFERENCES.

Colonial Report No. 24, 1903, Report on Land Settlement in Carriacou: by Hon. Edward Drayton, C.M.G.

Administration Reports, Commissioner of Carriacou, 1903 onwards.

Administration Reports, Agricultural Department, Grenada, 1909-10 onwards.

provide that there shall be no deduction of interest by reason of any part payment of an instalment.

17. (a) Land reserved for a village under rule 4 shall be called a 'Village Lot' and shall be laid out in house spots not exceeding 60 feet square each, with suitable space reserved for streets and cross streets to afford access to such house spots.

(b) For the purpose of valuation a Village Lot shall be treated as an allotment, and its value fixed as in rule 9 with the addition of all expenses attending its devision into house spots.

(c) The value of each house spot shall be apportioned so that the total valuation shall cover the total amount of the value of the Village Lot.

(d) Every allottee of an allotment shall be entitled to purchase and hold a house spot on the adjacent Village Lot, so long as any remain unsold, on the same conditions as an allotment may be purchased and held.

18. House spots may be sold or leased to persons who are not allottees and special cases dealt with on such terms and conditions as may be approved in each case by the Governor-in-Council.

19. The conditions of tenure of allotments shall be as follows:-

(*a*) Every purchaser shall for a period of 12 years reckoning from the date of allotment reside ordinarily in the island of Grenada, commencing to do so six months after obtaining a conditional permit under these regulations unless the Land Officer, with the approval of the Governor, shall otherwise permit.

(*b*) No land may be alienated, let or incumbered, for a period of twelve years from the date of allotment without the consent of the Governor.

The word 'alienated', does not refer to or include an involuntary alienation as in the case of descent or bankruptcy: nor an alienation partly involuntary as in the case of a devise by will.

(*c*) No exclusive right shall vest in any person to any spring, stream, pond, well, or other natural source of water situate in or flowing through any land.

(*d*) The Governor may at any time resume possession of any part or parts of an allotment not exceeding one-tenth of the said allotment, for roads, on paying therefor at the same rate per acre as that at which the allotment was originally sold, and also for the value of such crops as may be on such selected line or road.

(*e*) No cacoa shall be planted on any land for a period of twelve yearsfrom the date of allotment without the consent in writing of the Governor.

(*f*) All instalments and interest shall be punctually paid on or before the day of which they are due.

20. On failure by an allottee of an allotment or house spot to comply with any of the conditions of tenure hereinbefore

detailed, the Land Officer shall immediately report all the facts of the case to the Governor, who shall enquire as fully as possible into all the circumstances of the default, whereupon the Governor-in-Council may order that the right to such allotment of house spot, and all crops, and all instalments paid, and all other rights of the allottee shall be forfeited, without any appeal to any Court, or may make such other order as the circumstances of the case may require.

21. Notice of an order so made shall be served upon the allottee or left at his last known place of abode, and no act of re-entry shall be necessary, and such allotment of house spot shall be at the disposal of the Governor, either to re sell then or at any future time.

22. On payment in full by an allottee of the purchase money of an allotment or house spot he shall be entitled to a grant of the same. Such grant shall be in a form approved by the Governor-in-Council, and shall be recorded in the Land Registry Office free of all cost to the allottee, except stamp duty.

Approved and passed by the Governor-in-Council this 22nd day of April, 1910.

T. T. DYER.
Clerk of Councils.

BIBLIOGRAPHY OF REFERENCES.

Colonial Report No. 21. 1903, Report on Land Settlement in Carriacou : by Hon. Edward Drayton, C.M.G.

Administration Reports, Commissioner of Carriacou, 1903 onwards.

Administration Reports, Agricultural Department, Grenada, 1909-10 onwards.

METHOD OF WORKING SMALL HOLDINGS UNDER THE LAND SETTLEMENT SCHEME, ST. VINCENT.

BY W. N. SANDS, F.L.S.,

Agricultural Superintendent, St. Vincent.

The Land Settlement Scheme of St. Vincent is the largest and most comprehensive of its kind yet attempted in any other of the British West Indian Colonies A general account of the working of it from an agricultural standpoint was given in the *West Indian Bulletin*, Vol. XI, No. 3, of 1911.

The total area of the estates acquired or purchased under the scheme since the year 1899 now amounts to 7,527 acres. With the exception of the 400 acres of Belair estate, at present under survey, the whole area of cultivable land has been split up in small holdings. The size of the small holdings varies from 1 to 7 acres, but the larger number of them average about 5 acres each.

The estates are situated in different parts of the Colony, and climatic and other conditions as well as the crops grown and methods of cultivation show considerable diversity.

It would take too much space to describe in detail the small holdings in each district; besides, if an account were given it would probably contain a good deal of information not of general interest. These notes, therefore, will be confined to an account of the working of small holdings on one large group, namely, the Linley Valley estates.

The Linley Valley estates, acquired in 1899, have an area of 1,571 acres, of which a good proportion consists of land at a fairly low elevation. The annual rainfall ranges from 70 to 85 inches.

In common with the other Land Settlement estates, these estates have been visited at frequent intervals by the officers of the Agricultural Department and the systems of working now to be described have been evolved largely as a result of the instructions and advice given to the small holders from time to time by these officers.

An important fact is that the bulk of the produce of these small holdings is exported, and only a relatively small proportion, namely, that required for domestic consumption, is retained. The chief matter for concern at the outset was, therefore, the maintenance of the fertility of the lands; but the satisfactory condition of the holdings to-day bears striking testimony to the soundness of the methods advised and adopted.

The small holdings are situated on ridges and in valleys running down to the sea. The ridges occur at such short intervals that on practically all of the holdings, hillside cultivation has to be practised. The soil throughout is a light sandy loam of volcanic origin, in fact, the Soufrière volcano is only 5 miles distant and a large quantity of sandy ejecta was deposited on the lands in 1902 and 1903.

A donkey pen built of wood of Gru-Gru palm and thatched with Khus Khus grass. Young cotton and Indian corn in foreground.

Between small holdings on exposed ridges the Agricultural Department planted lines of 'Angelin' (*Andira inermis*) and 'Galba' (*Calophyllum Calaba*). These form efficient wind-breaks, and the prunings periodically provide considerable quantities of material for mulching and compost Of the two species of trees, the 'Angelin', which is a leguminous tree, has proved more satisfactory because, in the limited area of the small holdings, successful cultivation can be carried on close up to it, and it does not reduce the fertility of the soil; whereas the 'Galba' draws heavily on the plant food in the land for some 10 feet or more on each side of it, and crops suffer.

One of the first instructions given to the small holders was that no bush, grass or weeds were to be burnt, but were to be bedded into the soil or used to form compost heaps or thrown into the manure pens. Only very spiny or prickly bushes or trees classed locally as 'cassie', and old cotton stalks are allowed to be destroyed by fire. This has proved an excellent rule.

Donkeys are the animals chiefly used for transporting produce to the coast, and the majority of the small holders possess one or two. It has been possible, therefore, to get most of the people to erect donkey pens on their holdings. These pens, which are placed on the poorest parts of the land provide quite a large quantity of manure each season. Small stock, poultry and a cow or two are also kept on most of the holdings and these add to the manure supply.

Those small holders who live on their lands are in a better position still; there are few who do so on the Linley Valley estates, but on others, notably Clare Valley Questelles, the larger number actually reside on their holdings. The water supply which is not well distributed on the Linley Valley estates, is the controlling factor in this matter, and the people, therefore, prefer to live in villages on the estates where water for domestic use is readily obtainable at all seasons of the year.

The bulk of the lands being situated on sloping ground and steep hillsides, the question of drainage to prevent 'wash' has to receive constant attention. As a rule contour and diagonal drains are made and kept open; but even with these, heavy storm water occasionally does a considerable amount of damage. To keep up the sides of the drains and prevent scour, Guinea grass is extensively planted. This answers well, and at the same time provides fodder for stock. In places that wash badly or have been scoured out, plantains and bananas are grown, as well as the strong-growing Khus-Khus grass (*Andropogon muricatus*).

The crops grown for export are Sea Island cotton, tannias, sweet potatoes, arrowroot, cassava, pigeon peas and yams. On some of the holdings where there are pockets of soil of good depth, cacao is also successfully produced. For domestic use Indian corn is cultivated on a small scale, as well as bananas, plantains and breadfruit.

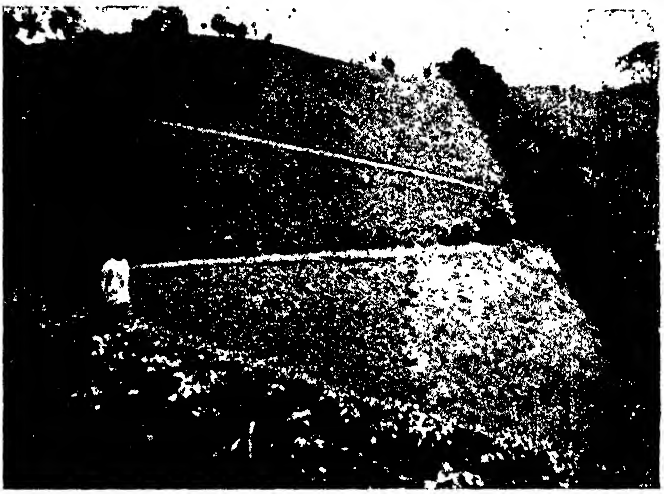
Local conditions vary considerably even on the limited area of this group of small holdings as well as the crops grown. It is proposed, therefore, to describe first of all the cultivation and cropping of a representative small holding where Sea Island cotton is the most important crop.

Sea Island cotton requires fertile land, so that a plot is usually selected that has been in pasture fallow for a year or more, or has grown a crop of pigeon peas. On the pasture fallow stock would have been penned at stake over the area, and such fodder as was available would have been fed to the animals on the ground. If pigeon peas had been grown these would have occupied the land for a year : but, on the other hand, the pigeon peas might have been sown between cotton of the previous crop and would not have produced a crop but would have been grown solely for green dressing purposes, as will be described later on.

In May, cultivation is commenced, provided the rains have come in. The selected plot of from 1 to 2 acres is cleared, and the weeds and the grass ranged off. If large plants of pigeon peas have to be dealt with, they are cut down and the small branches and leaves trimmed off. The root stumps and large wood are, however, thrown out and used as firewood The weedings and bush with any manure that may be available are ranged off in lines at right angles to the slope of the land. If the pigeon pea plants are young and not woody, they are simply cut down to the ground. Banks are then formed and the ranged material thoroughly covered with soil. The cotton seed is sown at intervals of 2 feet on the banks. Should a catch crop of Indian corn be desired, seed of this is sown in every other row in holes 6 feet apart. The Indian corn is reaped within four months from the time of sowing and the stalks pulled up and thrown into the manure pen. In the meantime, the cotton has received close attention in the way of cultivation, spacing, thinning, and moulding up.

About October the plants are bolling heavily and at this stage pigeon peas may be sown on every other bank at intervals of about 10 feet. By the beginning of the year all the cotton has been picked. The cotton bushes are then pulled up and burned and the pigeon peas allowed to remain. Should pigeon peas not have been planted previously, then sweet potatoes are planted and pigeon peas sown through them ; but to do this the cotton stalks have to be removed at the earliest possible date after the crop is reaped and before the dry season sets in. The peas are planted at a distance of 6 feet by 6 feet just after the cuttings of sweet potatoes have rooted. If a second crop of cotton is to be grown on the same land the following season, the peas are cut down and used as a green dressing If not, instead of planting sweet potatoes after the first crop of cotton, tannias or cassava are planted. Either, or both, will occupy the land for another nine to twelve months. Pigeon peas are planted after tannias or cassava, or the plot is allowed to revert to pasture, the latter practice being usually adopted. In a small part of the plot, well manured, yams are frequently grown with the other root crops. Sometimes with the tannia crop, six weeks beans, cowpeas and black eye peas are grown on the banks. This can be done with tannias because the tannia heads or slips are planted in holes in the furrows, and the beans are ready for reaping before the tannia plants cover the land.

Although tannias are largely planted on these particular estates, yet it should be mentioned that they require good land, a sheltered situation, and a rainfall fairly well distributed to



A typical Small Holding showing the 'Angelin' wind-breaks, and in foreground—cotton; left centre—ground provisions; right centre—pasture fallow; top—arrowroot.

produce full crops; cassava, on the other hand, although not grown here on any considerable scale is a more satisfactory crop on the drier coast lands of the Colony, and is a better crop to follow cotton. Again, it is by no means an uncommon practice for exposed coast lands to be worked successfully in cotton and peas, or cotton and pasture fallow. alone, for a number of years.

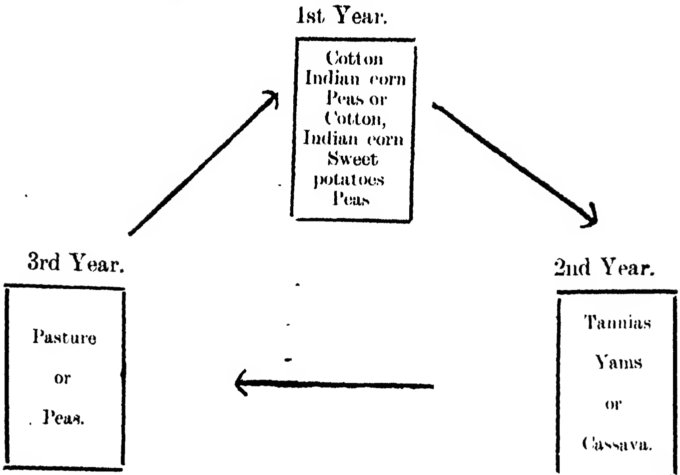
It will be seen that the Linley Valley systems above described, represent rotations extending over periods of three or four years. They may, of course, be varied under the influence of favourable market reports of particular products, but they are largely carried out and have resulted in considerable improvement of the small holdings.

It will be noticed that an important feature of these rotations is the free use made of leguminous plants to keep the soil in good physical condition, and to help to maintain the fertility of the land.

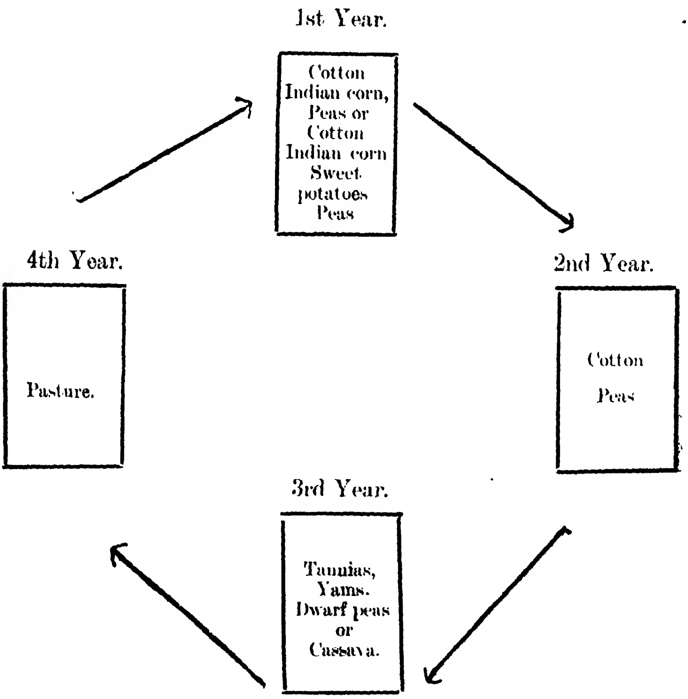
On those few small holdings where arrowroot is the chief crop quite a different system of cultivation has to be practised, because arrowroot may occupy the same plot of land for a number of years. Even in arrowroot cultivation the value of pigeons peas is not lost sight of, for after the arrowroot is dug, pigeon peas can be planted through the fields in holes 20 to 30 feet apart each way, so that when the reaping season comes round the bushes can be cut down and turned under in the process of digging the roots. Cotton is frequently made to follow arrowroot with satisfactory results, but the constant weeding out of the arrowroot plants that spring up proves rather a troublesome process. After cotton comes ground provision crops. Sweet potatoes with pigeon peas planted through them as described above is a satisfactory following crop owing to the smothering character of the vines.

The chief crops grown in small holdings in the higher and wetter mountain lands are sweet potatoes, tannias, yams, cassava and pigeon peas, and a somewhat larger number of plantains and bananas. Sugar-cane is also grown in small plots for the manufacture of syrup. Cotton will not produce satisfactory crops on these lands. No regular system of cropping is practised, except that free use is made of pigeon peas at regular intervals to build up the fertility of the lands as they become 'run down'. The practice of pasture fallowing is, however, extensively followed.

The three-year system may be set out thus :-



The four-year system thus :—



As mentioned in the earlier part of this paper, the bulk of the crops is grown for export, and it may be of interest to add a few notes on the markets, yields and prices realized for the different products. The Sea Island cotton produced is practically all sold to the Government Central Cotton Ginnery on a profit-sharing basis, which institution also supplies at cost price all the selected and disinfected seed required for planting purposes. In a good year, 700 lb. of seed cotton per acre may be obtained, but in an average of years it is probably 100 lb. lower. Everything depends on the distribution of the rainfall: in fact, at all times Sea Island cotton cultivation is a 'gamble in rain'. The average net price per lb. realized for seed cotton usually reaches 7c. per lb. For the 1911-12 crop season it was actually 9½c. per lb. for first grade seed-cotton. The average monetary return per acre from cotton is therefore from $42·00 to $49·00, without taking into consideration the value of the catch crops of Indian corn and sweet potatoes that may be grown.

Arrowroot yields from 8 to 10 barrels of starch per acre. As a barrel of starch contains 220 lb. net, this is equal to a production of 1,760 lb. to 2,200 lb. The starch is chiefly sold to local merchants for shipment to the English and intercolonial markets, the better grades only being shipped to the former. The prices obtained by small growers during the past two years have been much higher than usual. During the 1912-13 crop season as much as 5c. per lb. was paid. In average years, however, the price will probably be in the neighbourhood of 3c. per lb. and at this figure the proceeds would vary from $52·00 to $66·00 per acre.

Tannias are at the present time grown in preference to cassava. They are exported chiefly to Trinidad, Grenada and the Grenadines. An acre of land will yield 54 bags of tubers, termed 'seed tannias', which will net from 4s. to 5s. per bag. At 4s. per bag $51 84 would be received.

Cassava is grown principally on these small holdings as a catch crop in the arrowroot, tannia and cotton plots. A few plants at wide distances apart are cultivated and the roots converted into farine mostly for domestic use. Intercropping with cassava is nevertheless at all times discouraged. On other estates where there is a good water supply for starch mills cassava is grown as a crop to follow cotton. An acre of cassava yields about 10 barrels of starch, which is disposed of intercolonially. Last season, in common with arrowroot, prices were high as and much as 6c. per lb. was realized in Trinidad, where most of the starch is sold. If the average sale price be put at 3c. per lb. and the net weight of a barrel of starch at 220 lb., the amount received per acre would be $66·00.

The yield of sweet potatoes is put at 54 bags per acre, and if 3s. be taken as the average net price per bag obtained, then the monetary return is equal to $38·88, but in this case the crop occupies the land for only five to six months.

These notes give an idea of the value of the produce exported, but do not include the value to the small holder of the cacao, peas, plantains, bananas, sugar-cane for syrup, and bread fruit he may also grow and largely draw upon for home con-

sumption during the year; neither do they take into consideration the cost of working the small holding, and the expenses incurred in the preparation and marketing of the crops. These last items are somewhat difficult to arrive at, but the fact that most of the small holders on these estates are independent of estate work or other employment, makes it clear that they can, and do, make a fair living out of their lands for themselves and their families.

On the majority of the small holdings, as mentioned before, some live stock is kept, and it may be stated that the proceeds of the sale of the animals form quite important items in the small holder's annual receipts. The cattle that are raised are sold either to local dealers or shipped to the Barbados market. For some three or four years past good prices have been realized. Pigs, goats and poultry are shipped to Trinidad where they generally find a steady market at remunerative prices.

It will be noticed that with the exception of Sea Island cotton, the intercolonial markets are largely made use of for the disposal of the produce and stock raised on these small holdings.

The favourable geographical position of St. Vincent in relation to the other islands makes it possible to employ small schooners and sloops in this trade. These vessels which pick up the freight along the coast, carry it expeditiously and cheaply to its destination.

The appointment of agents in these markets is much to be desired in order to put this trade on a better footing. The present system of indiscriminate shipments often leads to unremunerative prices. If agents were appointed, they would be able to supply information at frequent intervals as to the possibilities of trade in particular products and stock, more particularly in regard to supply and demand and current prices; also, if not actually undertaking direct sales, they would be in a position to give the necessary advice to the small holder or his agent to enable him to obtain full market prices

An Ordinance (No. 9 of 1913) has been passed recently, which is likely to lead to still further improvement in the working of small holdings on these and other Land Settlement estates. This Ordinance has for its object the encouragement and assistance of Agricultural Credit Societies under the Raiffeisen system. The Government will make loans to registered societies and these in turn will be available on easy terms to members. Money may also be borrowed from private sources should circumstances warrant such action being taken. If, however, a society has already contracted a loan or loans from the Government, it will be necessary to obtain first of all the consent thereto of the Governor-in-Council before further amounts are borrowed. Under present conditions, it will be a comparatively easy matter to form societies on a sound working basis, with the result that the small holders who become members will be able to obtain loans to carry on the work of their small holdings to better advantage, and will not be hampered in their efforts for want of ready cash at critical periods of the year as so often happens at the present time.

A plot of tannias.

THE WEST INDIES AND CO-OPERATIVE CREDIT.

BY W. R. DUNLOP.

Scientific Assistant on the Staff of the Imperial Department of Agriculture for the West Indies.

INTRODUCTORY.

The repeated references during recent years to the subject of agricultural banks in the West Indian press, and in West Indian agricultural journals, leave little doubt as to the urgent necessity for improved credit facilities in regard to the cultivation of land in these colonies. Capital is required for the development of land in places like British Guiana, British Honduras, Dominica and St. Lucia, and, at times, in almost every colony in connexion with the management of estates already established. But the chief and the most pressing demand for capital occurs amongst the peasant proprietors, whose numbers are rapidly becoming greater as the various land settlement schemes materialize. It is principally this demand of the small owner that is considered in the following pages. As is pointed out by the writer in an editorial article in the *Agricultural News*, the subject of agricultural banks, or what is perhaps more exact, the subject of co-operative credit is approached in this paper, first of all, by giving a chronological review of the efforts made to establish credit systems in these colonies during the past ten years. Following this an account is presented of the progress that has been achieved in India, and in tropical or sub-tropical possessions other than the West Indies: whilst in the third and final section of the paper is discussed future possibilities in the West Indies, including a consideration of the present difficulties in so far as the experience in other tropical or sub-tropical countries help to solve them, or help to suggest new lines of effort. Appended to the paper will be found reproduced the recent St. Vincent Ordinance for the encouragement and assistance of agricultural credit societies, and a report on the working of the same, written by the Secretary of the St. Vincent Administration Committee.

HISTORY OF THE MOVEMENT IN THE WEST INDIES.

A committee had already been appointed by the Trinidad Agricultural Society to report on the question of agricultural banks, when in June 1899 a motion was moved that the Government should be approached to assist in the matter. It was decided to await the report of this committee, which was eventually read before the society in August of the same year. It advocated the formation of credit societies of the Raiffeisen

pattern and suggested that the Agricultural Society could assist by awakening a spirit of initiative and by its members individually working in conjunction with the clergy and schoolmasters in accordance with the Raiffeisen principles. The Government, it was suggested, might assist in the matter by issuing gratuitous literature on the subject, and by appointing agricultural instructors, part of whose work should be to arouse the interest of the peasants.

In November of the same year a paper was read on co-operative agricultural banks before the society and the working of these institutions in Europe was described in some detail.

In 1903 some attention was given to the subject in British Guiana, when Mr. Luke M. Hill read a paper on rural agricultural banks for British Guiana, before the Royal Agricultural and Commercial Society of that Colony. This communication referred principally to the work done in Ireland.

It was not, however, until early in 1905 that the subject was brought definitely before the West Indies. At the Fifth West Indian Agricultural Conference under the Presidency of Sir Daniel Morris, a paper on Raiffeisen Agricultural Banks was read by the Hon. W. Fawcett, B.Sc., Director of Public Gardens, Jamaica. The necessity for loan banks on a popular basis in Jamaica, and in the West Indies generally, was pointed out. Reference was made to the Hurricane Loans Law of 1903, the precautions in the covenants of which were similar to the rules laid down by Raiffeisen as regards the requisite qualifications for the borrower, but they did not go as far, and did not include unlimited liability. Neither was the very poor man reached.

In the discussion which followed this paper, reference was made to attempts that were being conducted in British Guiana to start co-operative banks there. It was pointed out that in that Colony, climatic extremes had to be faced that were to a large extent absent in Europe. This tended to make it difficult to limit the period of repayment of loans. Moreover, there were difficulties in connexion with the mixture of different races in British Guiana.

During July 1905, the Jamaica Agricultural Society brought up the subject again. Cases in which district credit associations could do good work were cited, but the circumstances of these cases did not involve true Raiffeisen principles but were rather deserving cases accompanied by real security. The idea of unlimited liability was not involved. Nor were official views on the possibilities of mutual credit very optimistic at this time, as is evinced by the statement that to establish a similar system to the Raiffeisen in Jamaica would require 'a large amount of persistent missionary effort.'

Pursuing its policy of encouragement, the Imperial Department of Agriculture for the West Indies issued, in 1905, as a pamphlet, Fawcett's and Hill's papers already referred to; and in 1906 published an article in the *West Indian Bulletin* on agricultural credit in Germany. This gave a concise account of the Schulze-Delitzsch banks, the Raiffieisen banks and the numerons German Central banks.

In 1907, the Barbados Sugar Industry Agricultural Bank was established. This institution had for its object the administration of the free grant of £80,000 made in aid of the sugar industry of the island by the Imperial Parliament. Loans, which could only be expended in connexion with the cultivation and management of the estate (except with the express permission of the Directors) were made to planters at 6 per cent. interest on the security of the growing crops.

Although the fund originally granted was in aid of the sugar industry, it was afterwards extended to include cotton. In this connexion, it may be mentioned that during the same year (1907) an Act to regulate advances in aid of the cotton industry was passed in the Leeward Islands.

About this time the Trinidad Government were considering the establishment of a Government Agricultural Loan Bank following the dissolution of the Trinidad People's Bank instituted a few years before. This latter establishment failed to assist the small holder and did not strike the foundation of all rural co-operative concerns, namely, the freeing of the peasant from the money lender.

Nothing seems to have happened, however, for at a meeting of the Trinidad Agricultural Society, in September 1908, a letter was addressed to the society again advocating the establishment of agricultural banks. After some discussion, it was decided to adjourn the matter generally until the appointment of the new Governor, and until the new Agricultural Department was on a working basis.

Consequently, at the Eighth West Indian Agricultural Conference, Sir Daniel Morris in his Presidential Address was unable to refer to any great advancement, though there were in operation at this time the Trinity Ville Bank and the Christiana Bank in Jamaica, and the Government Loan Ordinances. It was suggested at this meeting that, in view of meeting the requirements of small rice growers in British Guiana, advances might be made on the lines of the cotton loans in the Leeward Islands already referred to, or efforts made to start co-operative loan banks on the lines of those existing in Jamaica. It was emphasized by Sir Daniel Morris that in regard to the latter, it was important to bear in mind that each bank should deal with a limited area, so that those who advanced the money might be immediately in touch with the borrowers, and might therefore be able to judge for themselves as to the manner in which the money was applied.

In 1907, the Board of Agriculture of British Guiana made another effort to arouse public interest in that Colony through the medium of their journal. Government aid and encouragement, both direct and indirect, were asked for towards the formation of Raiffeisen banks modified to suit the conditions obtaining in British Guiana.

During the same year St. Vincent awoke to the necessity for rural credit facilities, and the St. Vincent Credit and Loan's Bank, Limited, was started. It was proposed to issue 5,000 shares

of a dollar each but a comparatively few number of these shares were taken up at first.*

After a period of comparative quiescence, Trinidad recommenced an agitation for co-operative banks towards the middle of 1909. Mr. G. C. Wyatt who had three years before made the same appeal, moved a motion at a meeting of the Agricultural Society advocating the establishment of credit banks. After discussion it was resolved to appoint a committee to consider the question, and to advise suitable regulations for the proposed banks.

The Interim Report of the committee appeared in August of the same year. The committee was of opinion that a sufficient feeling of distrust existed, partly as the outcome of the failure of the People's Bank, to render the establishment of purely co-operative banks difficult, if not impossible. Reference was made to the Barbados Sugar Industry Bank, to the Philippine Agricultural Bank, to the St. Croix (D. W. I.) Sugar Loans Ordinance, and to the Cyprus Agricultural Bank, all of which were Government aided but not unlimited liability companies. It was suggested that the Government of Trinidad be approached and asked to assist in the establishment of a bank or banks.

Meanwhile, in British Guiana (1911), the committees appointed by the Governor, Sir F. M. Hodgson, had issued their reports, and the second one, of which the proposals were clear and decisive, recommended the institution of a credit bank and the extension of the credit given by it, to other than purely agricultural purposes. It rejected the principle of unlimited liability (which is of course the principle of the Raiffeisen system), and adopted Government aid and Government supervision. It was intended to benefit co-operative members only. The interest on loans was fixed at 12 per cent. In regard to the question of liability the report ran : 'But we think that banks with unlimited liability are unsuitable for introduction into British Guiana at present. They are no doubt suitable to the more sophisticated people of European nations who know their neighbours and can watch and check their work ; but the people of British Guiana are not in the same position. They are averse to watching and checking their neighbours' affairs, and would not take kindly to the responsibility of having to make good their neighbours' defaults. We accordingly recommend the adoption of banks in which membership is dependent upon taking a share or shares.'

*The Bank was opened on March 3, 1909. At the present date (December 1913) there are 440 members. The share capital is $20,000·00 in $1·00 shares ; 6,264 shares have been taken up and 50 per cent. the value of each share paid, which represents $3,132·00. Loans made to the bank bring up the total working capital to $5,324·00. This represents the actual cash liabilities. About $5,000·00 are out on loan. Loans are made to members from $10·00 to $100·00, but the latter amount is rarely exceeded. The interest charged on small loans is 6 per cent. for three months, and on large loans 4 per cent. for a similar period. The bulk of the money out on loan is at present in the hands of small holders, and therefore devoted to agricultural purposes.

Turning to the progress of the movement in Trinidad, it appears that in November 1911, a statement was made at a meeting of the Agricultural Society to the effect that the committee appointed in August 1909 to consider the subject of agricultural banks had collected a great deal of information and trusted soon to be able to send in their report. This investigation work of the committee followed on a reply from the Government in answer to the appeal for assistance made by the society in 1909. The reply of the Government was to the effect that they would do anything in their power to assist in the establishment of an agricultural bank, provided a concrete scheme could be formulated on which the institution could be successfully worked. The Government also requested definite statements as regards the extent of the loan, the rate of interest that would be charged on borrowed money, and the limit that could be placed on the members' loans. The committee, in order to answer these questions, collected evidence as already stated, and put forward their report (the second) in 1911. As far as can be learnt from the society's records, all this committee was able to do was to suggest the formation, in Trinidad, of a similar bank to that proposed for British Guiana, an account of which has already been given. No definite action seems to have been taken, for in July 1912, a letter was read at a meeting of the Agricultural Society saying that the Governor had appointed a committee to consider and report as to the establishment of agricultural banks, and requesting that the society would nominate two representatives.

Meanwhile, in Jamaica, although the start which had been made in the form of the Christiana Bank had been maintained, there was little development to record. The establishment referred to was described in April 1911 as having been increasingly useful, and it was urged that the branch agricultural societies in other districts in Jamaica should take an interest and help to start other institutions of a similar kind. Later in the year (December), Mr. Cradwick reported on the Christiana Bank to the Director of Agriculture. He found that most of those doing business with the bank were small holders and had the privilege of seeing loans issued for 'buying a mule', 'planting bananas', 'cleaning a field', and such like desirable purposes. The working capital of the bank was raised entirely by shares, which were not withdrawable but transferable with the sanction of the Board of Management. The interest charged was 2*d.* per £ per month (= 10 per cent. per annum). Loans were made for six months only and no security was required beyond two signatures to the borrower's promissory note : but the sureties were given to understand in the plainest language, that if the loan was not repaid they would be sued. A lawyer was retained for this purpose. The loans issued generally varied between £1 and £20.

The successful working of the Christiana Bank and the unfortunate liability of Jamaica to climatic extremes and other natural disasters evidently led the Government to pass in, May 1912, the Loan Banks Law (No. 6 of 1912). This Ordinance made it lawful for the Governor to appoint an Agricultural Loan Societies Board with power to enquire into the proceedings of all agricultural loan societies which might apply to the Gov-

ernment for loans that would be issued from funds voted by the Legislative Council. Under this Act the Government could advance a local loan bank, duly organized, up to two-thirds of its share capital without the shares being actually paid up in cash by the members. In December, however, of the same year (1912), the widespread damage occasioned by the storm of that year led the Government to amend the first law and pass a fresh one entitled The Agricultural Societies (Special Loans) Law. By this enactment, so long as local loan banks were organized, they were able to make loans to freeholders (and under certain circumstances to tenants of land) who must first become members of the local bank, and make their repayments, which would be spread over two years, or could be paid in a lump sum at the end of two, into the local bank. When the shares were paid, the total amount was to be the capital of the bank and be available for future loans in the ordinary way of loan banks, independent of Government aid. The interest charged by the Government to the loan bank was fixed at 1 per cent.; the interest charged by the local bank to borrowers was 6 per cent.; the difference being required for the working expenses of the local bank, with any balance going to the reserve fund.

The establishment of banks was naturally stimulated by this Act, and by the middle of 1913 they had been instituted in nearly every parish. It will be understood that these banks were all conducted on a basis of limited liability and not managed according to the Raiffeisen system.

Reference has already been made to the awakening in St. Vincent during 1909. The need for co-operative credit in this Colony was due largely to the introduction of the Land Settlement Scheme. Accordingly, the demand for banks, having a very definite and stable economic cause, it could not disappear. It is not surprising, then, to find that in January 1911, another credit society was formed under the name of the Questelles and Clare Valley Agricultural Credit Society. For the purpose of its inauguration, a meeting was held between twelve peasant proprietors in the district and one of the parochial ministers of religion. It was resolved to register the society, and rules for its conduct were passed. The society was subsequently granted a loan of £25 by the Government.

Since that time up to the present, the general adoption of land settlement schemes in all the Windward Islands has rendered it more and more imperative to provide opportunities for the establishment of co-operative credit societies. Quite recently the St. Vincent Government has passed an Act* (No. 9 of 1913) for the registration, encourgement and assistance of agricultural credit societies under the Raiffeisen system. This enactment has been the first and only attempt on the part of any West Indian Government to legislate in favour of the Raiffeisen system, and its effect will be awaited with interest.

As might be expected, this Act has aroused considerable interest in the West Indies, particularly in Trinidad where copies of the Act have been distributed amongst the members of the Agricultural Society and published in the Bulletin of the

* See Appendix.

Department of Agriculture. Grenada is contemplating similar legislation also; though from a recent message from the Trinidad Agricultural Society to the Agricultural Society of Grenada asking for information in regard to agricultural credit legislation in Grenada, it would seem to appear that the Government had already taken action.

British Guiana, like Trinidad, has still to face the problem of rural credit. The local press has recently (December 1913) ventilated the subject, and it is expected that at an early date the Government will announce a definite policy. Public opinion in this Colony seems to be, and rightly so, that the Government should not sink large sums in credit establishments unless there is a fair degree of certainty of the borrowers keeping strictly to their side of the bargain. As a matter of fact, the move should come from the public, and then the Government seeing definite evidence of a desire to co-operate for mutual benefit, would be more ready, it is believed, to render material assistance.

We cannot conclude this review without referring to the recent decision of the Government of St. Croix (D.W.I.) to advance money for assisting sugar-cane cultivation at the low rate of interest of 4 per cent. It would appear that the system adopted resembles very closely that of the Agricultural Bank in Barbados—an institution which has progressed with the greatest success. The money is loaned on the security of the growing crop and must be expended on reproductive purposes connected with it. Such sources of credit, however, do not benefit the very small cultivator but rather the larger estate owners. As already intimated, little has been done in the West Indies to provide credit facilities for the peasant proprietor except in Jamaica and St. Vincent, and even in these Colonies the systems have never been such as are likely to secure continuous development, and effect social improvements as well as purely economic ones.

RESUMÉ.

We have now sketched in outline, the chief efforts that have been made in the West Indies and British Guiana to provide credit facilities for the peasant proprietor from 1899 to the end of 1913. We have seen that the agitation began with appeals for Raiffeisen banks first in Trinidad, then in British Guiana and Jamaica. But the agitation was ineffective as regards the Raiffeisen system of co-operative credit. In fact, little has been done to introduce a credit system of any kind for the benefit of the small holder except in Jamaica, and here it was only in the face of natural disasters and with copious financial fostering on the part of the Government that anything has been actually done. It must be admitted, however, that in regard to St. Vincent, prospects of development at the present time are favourable. In Trinidad, the records merely show a rotation of motions, committees and reports, and one can only conclude that the social and economic conditions obtaining in this Colony present almost insuperable difficulties. Yet the fact remains that in Trinidad, the Windward Islands, and British Guiana to-day, the need for co-operative banks is greater than ever it was. A big economic problem, therefore, urgently awaits solution

Agricultural Credit in India and in Tropical Possessions other than the West Indies.

Most of the previous literature on agricultural banks for the West Indies has dealt principally with credit movements in Western Europe. In this paper it is proposed to review as far as possible such efforts as have been made in parts of the Tropics other than the West Indies. Any successful results that have been obtained there will, it is believed, be more applicable to West Indian conditions, and the failures may help to solve some of the West Indian difficulties.*

Co-operative Credit in India.

It is a rather interesting circumstance that the co-operative credit movement in India commenced about the same time that that subject first received definite attention in the West Indies. But whereas, as we have shown, there has been no satisfactory development to record in the matter for these colonies, in India, the measures introduced ten years ago have proved a success beyond the dreams of their most enthusiastic advocates.

The initial step was taken by the Indian Government when it passed, in 1904, the Co-operative Credit Societies Act. This provided for the registration of co-operative societies consisting of ten or more persons above the age of eighteen years. The members were required to reside in the same town, village or group of villages, or (subject to the special sanction of the Registrar for the Province) be persons belonging to the same tribe, class or caste. The societies were divided into two classes, 'rural' and 'urban'. A rural society was defined as a society in which not less than four-fifths of the members were agriculturists, whilst an 'urban' society was one in which not less than four-fifths of the members were non-agriculturists.

In the case of the rural society, the Act provided that the liability of the members should be unlimited, save with the special sanction of the local Government. In a society with unlimited liability each member was allowed only one vote at the general meetings of the society. In the case of a limited liability society the number of votes per member was to be decided by the bye-laws.

The Act required all profits of a 'rural' society to be carried first to the reserve fund; but as soon as this reached a certain proportion of the total liabilities, or the interest on the loans reduced below a certain percentage, the distribution of a bonus was allowed.

In an 'urban' society, at least one-fourth of the profits had to be allocated to the reserve fund: but the law made it legal to distribute the remainder as a bonus or dividend.

Loans could only be made to members, except that an 'urban' society could lend money to a 'rural', and *vice versa*.

* As we go to press the writer understands that both Trinidad and British Guiana are now (1914) giving definite attention to co-operative credit systems in India. In view of the large coolie population in these Colonies, it is somewhat surprising that action along this line did not suggest itself earlier.

The Governor-General in Council was empowered to exempt societies from taxation and each local Government had to appoint a Registrar. The powers of the Registrar were made very wide, particularly in the matter of inspection and enquiry, and an important duty of this officer was to be the auditing of the accounts of each society in his district at least once a year.

WORKING OF THE ACT AND GENERAL PROGRESS.

The wonderful strides made under this Act will be appreciated from the fact that by 1912—in eight years—India possessed 8,177 co-operative credit societies having a total membership of 403,000 and a working capital of £2,238,000. The amount issued in loans during the year 1911-12 was £1,191,000.

But success was not attained without initial difficulties having to be surmounted. Apparently before the influence of the Act had been felt, the Registrar for the United Provinces classified these difficulties as. (1) those relating to the *personnel* of the society (-caste) : (2) its rules and accounts (3) : the raising of capital. To these may be added (4) difficulties in connexion with the travelling of Registrars when on tour. Difficulties connected with caste were solved by the 1904 Act, as was also the problem of raising capital. In regard to this latter question, the Government placed money at the disposal of the Registrars, but limited the amount which might be lent to any society to a sum equal to the amount actually deposited by the members. But as well as this Government assistance, there occurred a good deal of semi-philanthropic investment, and a considerable amount af borrowing on the part of the societies, in later years, from joint stock banks.

Considerable liberty was allowed by the Act in regard to the choice of system to be adopted. In a vast country like India, with its varied peoples and climate, no one system could possibly suffice. The most usual type adopted was the Raiffeisen, generally without shares, but sometimes with shares. The Schulze-Delitzch and the Luzzatti type also appeared in some places. The reasons which might determine the choice of a particular type of society naturally varied very considerably. In Burma, for instance, the Luzzatti type was favoured because the peasantry of that Province were better off than the Indian peasantry, but were more improvident and required to be taught the virtue of thrift. In the Luzzatti system there is a bank account, and this appeals to human nature more directly than the Raiffeisen system. Yet as was pointed out by one of the Registrars, the members of a Raiffeisen society will hold more property *outside* their society, and the members of the other type will hold more money *in* their society.

Turning to the subject of the duration and repayment of loans, it appears that during 1908-9, the average duration was about a year. For some time, as might be expected in the case of an improvident people, considerable trouble was occasioned in regard to repayment. In Bengal, it was at first found necessary to limit all loans irrespective of purpose to one year, and although opposed to the Raiffeisen principle, it was necessary to the education of thrift and punctuality of the coolies. Afterwards this rule

was altered, and a loan for the cultivation of a particular crop was repayable when that crop was harvested ; loans for purposes which yielded profit more slowly were recovered in installments over a term of years.

The average size of loans was about 20 rupees (£27) in Bengal and 100 rupees (£135) in Madras.

The purposes to which the loans were devoted also showed variation. During 1908-9 in Madras, 15 per cent. of the total amount loaned was utilized for trade purposes, the remainder being chiefly invested in agriculture ; in Bengal 25 per cent. was devoted to cultivation expenses and 35 per cent. to the repayment of debts. The lending of money for marriage and other ceremonies might scarcely seem to come within the functions of an agricultural bank, yet in Bengal nearly 3 per cent. was advanced for these purposes. The explanation is simple. Unless it were permitted the members would raise much larger sums from money-lenders at exorbitant rates of interest. Indirectly the lending of money by the banks for these purposes educates the members to restrict expenditure for such unproductive purposes.

The success of co-operative credit in India is seen from the fact that the average rate of interest on bank loans fell to about 12 per cent., whereas that on loans advanced by money-lenders averaged about 20 per cent., or over. Even the money-lenders themselves have been influenced by the organization and in some places have lent money to the banks themselves, realizing that a certain and regular payment of a smaller interest is better than an uncertain exorbitant one.

It will be readily understood that as the number of banks increased, a need was felt for central societies. During recent years the number of these has increased rapidly. Their function, generally speaking, is to finance and to supervise the affiliated banks. In Bengal the central societies have become regular federations. Each seeks to develop co-operative societies within its area and to carry on banking business with them, besides exercising a controlling and regulating influence and settling all matters of joint importance.

Although most of the central societies were constituted on a limited liability basis, some, on the other hand, arose on the principle of unlimited liability. Such, for instance, was the Kirnapur Society in the Central Provinces, the members of which were rural societies which had accepted unlimited liability. As far as information is available this remarkable—one might almost say ideal—organization has worked quite satisfactorily.

These central banks obtained their capital from different sources. There were first Government advances : these have shown a tendency to decrease. While societies are in an experimental stage and their establishment is to be regarded as educational, advances by the Government are advantageous, and at the outset perhaps essential. But the aim should be to obtain money for business purposes from business sources. The favourable terms of Government loans obscure the real commercial position of a society.

The other sources of capital were deposits by members, loans from other societies from non-members, and loans from joint stock banks. This latter source is of much interest and improtance and will be referred to again later on.

CAUSES OF SUCCESS.

Having now presented a brief review of the putting into successful action of co-operative credit amongst the people of India, one naturally inquires—To what was the success due? The causes of success appear to be :—

(1) The existence of a Central Government to lay down the general principles, and local Governments to carry them into effect in detail.

(2) The individual organization and missionary work of the Registrars.

(3) Government advances.

(4) The regard shown for human nature, for customs and local circumstances.

(5) 'Honorary' assistance both in regard to organization and semi-philanthropy.

CO-OPERATIVE CREDIT IN TROPICAL POSSESSIONS OTHER THAN INDIA AND THE WEST INDIES.

With the exception of Egypt, not a great deal appears yet to have been done to provide easy credit for the small holder in tropical and sub-tropical countries other than India: though that which has been done presents several points that are interesting and suggestive. In Ceylon some progress has been made in the matter of agricultural banks, but in this Colony co-operative seed and manure supply stores seem to have been found better suited to the requirements of the villagers. A small store of rice, for instance, is opened by the assistance of local capitalists or of the Government, and from this store, the villagers can get their seed rice at an interest of, say, 12 per cent. paid in kind at harvest time.

The problem of organizing rural credit in German West Africa has for some time received the attention of the Imperial Government. One regards naturally with great interest, any attempts made in this direction by the country where the theory and practice of rural credit are so notably efficient. But in contrast with the great progress made by rural credit in Germany, it must be confessed that the Colonies of the Empire are still almost virgin soil in the matter of organization of such credit. The important proposal has been made that inspectors acquainted with Raiffeisen credit organization in Germany should be sent out by the Imperial Government to report on conditions and perhaps organize a system in the German colonies. The problems which are to be confronted in Africa are naturally different to those obtaining in Germany; and also, it may be added, to those in the West Indies. Cultivation is of an extensive character and capital for big permanent improvements and for extensive stacking is required. It has been suggested in

Germany that all the profits from sale and lease of lands should be handed over by the Governments to a State Credit Bank, which would, however, be quite independent of Government control. More satisfactory seems to be the Rhodesian system. Here the Government of that country has established a Land Credit Bank the loans advanced by which must be invested in reproductive work. Since the farmer's ability to repay increases each year, repayment is arranged on an increasing scale. It should be mentioned here that quite recently a loan bank has been established by the Government in German South-west Africa. An important and significant function of this bank is to lend, without real security, working capital to co-operative credit societies.

In French West Africa considerable success has followed the introduction of a system of thrift societies. Senegambia, one of the Protectorates, depends on a single crop: that of ground nuts. It is very necessary, therefore, that the natives should have the necessary amount of seed to sow before the rainy season. To ensure this, the Government founded seed stores from which seed was loaned on condition that it should be returned at harvest time together with 5 per cent. interest. These worked successfully, and the natives invested their seed: but unfortunately, as development began to take place the rate of interest was suddenly raised and the consequences were soon felt in a reduction of the number of members during the following year. Definite regulations have now been passed but they seem open to criticism.

Before leaving the subject of agricultural credit in Africa, a brief account may be given of existing organizations in Egypt. There is first of all, the Agricultural Bank of Egypt. This institution was founded by Lord Cromer to free the improvident fellah from the clutches of the Greek money-lender. Although not a co-operative concern, it is of interest from the West Indian aspect, inasmuch as it is an external attempt to improve the conditions of the small holder. It is a mortgage bank, but work is done with so small a portion as ½-acre of land as security, though it must be remembered that the value of cultivable land in Egypt is relatively very high. The instalments are collected by Government collectors, and names of defaulters are sent to the bank through the Government.

Although this bank was looked upon as a more or less philanthropic concern, it pays a regular 7 per cent.

In Tunis a system of agricultural mutual credit exists. Small societies on the joint and several liability of their members lend small sums for agricultural productive purposes. Natives are admitted as members as well as the French farmers, the fact being realized that collective prosperity increases the value of the larger estates. Among the mutual credit institutes is a regional bank with headquarters at Tunis. The Regional Bank does not lend directly, but to groups of lenders constituting the local banks, each of which invests its capital in regional bank shares. So useful have these societies been found that the membership is rapidly increasing in spite of the precepts of the Koran, which forbid any good musulman, not profit on a loan, but interest in proportion to the length of time for which it is borrowed.

The Position in the West Indies.

Careful consideration of the facts presented in the preceding pages makes it appear that in the West Indies systems of agricultural credit are required which will serve, broadly speaking, two classes of landowners: firstly, those who cannot offer real security, and secondly, those who can. The former class may be considered first. During the past ten years, there has been a land settlement movement in the West Indies, the object of which has been to remove the evil discovered by the Royal Commissioners in 1897. Apart from Government land settlement, there has also occurred, during recent years, a voluntary splitting up of the larger estates in many places, and there now exists a large class of peasant proprietors who from time to time urgently require small amounts of working capital, that is capital for reproductive purposes on their one-acre or five-acre holdings. Particularly in some of the larger land settlement districts, where members of the community are in close contact, a system of mutual credit is eminently desirable—as desirable as a system of mortgage credit is, for obvious reasons, undesirable. For these, societies of the Raiffeisen type, or the Raiffeisen type slightly modified, should prove useful and work satisfactorily.

The demands of the second class of landowners—the holders of larger properties—cannot, it is believed, be easily met in this way—at least not at first. For such landowners, a co-operative loan bank is wanted—an institution whose object is to facilitate land developement, particularly, in colonies like British Guiana, British Honduras, Dominica, and St. Lucia. As well as doing this, the loan bank would assist in the matter of providing working capital in the way that the Barbados Agricultural Bank does. It is very necessary to regard the demands for credit of the small and large landowner separately. And the reason why is obvious, when we come to consider the method of establishing the banks. In starting an unlimited society on the Raiffeisen system, the essential thing is to begin in a very small way, to restrict the area of operations and the number of the members of each bank. In a limited concern, the larger it is the better. With the Raiffeisen system, each bank is a unit, and the aim should be to increase the number of these units and eventually establish co-operation amongst them in order that a central bank may be formed, which will correspond very closely to the land credit bank for the larger proprietors. This latter point however, affects the future more than the present, and we may turn now more profitably to a consideration of the conditions of establishment.

It is not necessary here to dwell upon the wonderful strides which we have seen to have taken place in regard to mutual credit in India, nor to treat again at any length the subject of the successful establishment of land credit banks in German West Africa, Tunis, Queensland, Rhodesia and in other tropical or sub-tropical countries. But it is necessary to dwell upon this fact, that the success in India—in a country, be it remembered, offering far greater social difficulties, and a far wider range of general conditions than the West Indies—success in India has been due not to Government money, but to Government organization. In the West Indies there have been spasmodic

monetary grants from the Governments for purposes of capitalization, and although in the initial stages of mutual credit banks, and indeed of the larger limited banks, Government capital is desirable, perhaps, absolutely necessary, it is not in this direction mainly that the money ought to be regularly expended. To be independent of Government capital should be the bank's principal aim, because the favourable terms of Government loans obscure the real commercial position of the society. But in the direction of providing a staff of registrars and inspectors—a special credit department—financial assistance may very well be given by the State. Benevolent control and energetic stimulation are, indeed, the first essentials. Added to this it is necessary to have uniform legislation. St. Vincent has been the first to take any definite step in the West Indies in regard to legislation to encourage the Raiffeisen credit system. The Ordinance, which has recently been passed, provides for the registration and for the provision of capital to properly accredited societies ; but it does not appear to make sufficient provision for Government supervision, and for that missionary work which will be necessary in the early stages. It may be understood, however, that this important side of the movement will not be neglected. In India, a great deal of help has been afforded by 'honorary' promoters, and it may be expected that the same interest will be shown in St. Vincent. It is not likely, however, that the people themselves will move, or, if they do, will achieve satisfactory results unless there is a benevolent but firm guiding hand.

There is reason to believe that agricultural credit societies in St. Vincent will receive assistance from the Friendly Societies. This would be likely to prove very helpful as a means of encouragement, and possibly as a source of capital. It will be remembered that in India the requirements of the people as regards loans for ceremonial and other non-productive purposes are met by the agricultural banks. In the West Indies, the peasants commonly rely upon the Friendly Societies for such advances. It is a question worth considering whether the granting of loans by credit societies for purposes other than agricultural, might not stimulate the investment of capital in these banks.

Whether the example set by the Government of St. Vincent will be followed by other Governments remains to be seen. The step will no doubt be regarded as an interesting experiment, and the results cautiously awaited before any extensive action is taken. From the idealistic standpoint, a general Act for the whole of the West Indies, to lay down the general principles on which credit systems are to be managed is desirable ; though the actual application of them must be left entirely to the local authorities. Unfortunately, under existing conditions, this is impossible, and each island will follow its own policy. It cannot be denied, however, that agricultural credit affords a strong argument in favour of Federation.

As is already intimated, it is as yet too early to discuss the question of central banks and the employment of joint stock banks as a source of capital. There is no harm, however, in keeping the future in view. It took, in India, only two years for the need of central banks to be felt. According to the latest information, six

societies have already been registered in St. Vincent and a definite move is stated to be taking place in Trinidad. A large number of societies will not be able to exist to the best advantage, independently. A central organization, even if only to handle surplus capital, will soon become necessary. It is highly important to bear in mind that organization is in itself security. On this security, in England and in India, satisfactory arrangements have been made between societies and joint stock banks by the Government, whereby capital can be obtained by societies from this source at reasonable rates of interest. With the present spread of banking establishments in the West Indies, such an arrangement, in time, might be equally possible. It is of interest to bear in mind the fact that capital is scarce in Canada and commands a high rate of interest. So that for the present it might be considered likely that any banking establishment in the West Indies connected with Canada would be more ready to give high rates of interest on the surplus capital of amalgamated credit societies rather than lend these societies capital at a low rate of interest. Similarly it is to be considered probable that English banks would be more ready to make loans. The relation between joint stock banks and agricultural credit societies is a matter of great importance, and an investigation of the question will be one of the lines of co-operative activity in the future.

We cannot conclude these general remarks without some reference to the probable value in the West Indies of co-operative seed, manure and insecticide societies. In Ceylon, Tunis and Senegambia, considerable success has attended the establishment of such organizations, particularly where local conditions will not, for the present, allow of the formation of money-lending societies. The subject has received some attention in Grenada, but, of course, the rate of progress along this line of co-operative credit will largely depend upon the extent to which the Government will continue to provide seed and insecticides and the like free of charge or at a reduced cost. The question brings up once more the subject of the expenditure of public funds for agricultural purposes. The simplest course, and the one involving least trouble, is to lend or give material assistance direct; but the reader will have realized that in the opinion of the writer, the best policy and the one calculated to have most lasting effect is to expend public funds upon the appointment of public officers, whose duty it is to encourage self-help and thrift, and to back up legislation related thereto by means of personal contact with the people themselves.

REFERENCES.

The following is an alphabetical arrangement comprising the main points dealt with in the preceding pages and other matters relating to credit not touched upon in the paper, together with the references to them.

Those points directly connected with agricultural credit in the West Indies and in the Tropics and sub-tropics generally will be found under the colony or country to which each refers. Geographical grouping is not adopted in the case of matters pertaining to credit systems of temperate countries.

A.

Agricultural Bank in Chili, *M.B. of Econ. & Soc. Intell.*, 4th year (1913), No. 4, p. 115.

Area of activity of banks, restriction of by law in Japan, *M.B. of Econ. & Soc. Intell.*, 4th year (1913), No. 1, p. 28.

B.

Barbados Bank. *W.I.B.*, Vol. VIII, p. 366; *Agric. News*, Vol. VII, p. 49.

Book-keepers in rural banks, instruction for, in Austria. *Journ. Board of Agric.*, England. Vol. XV, p. 870.

British Guiana, East Indians in, *Timehri*, Vol. 2, No. 2, pp. 305 and 309.

— — Government aid, appeal for, *Journ. Board of Agric.*, Br. Guiana, Vol. II, No. I (1908).

— — loan bank proposal, Demerara *Daily Argosy*, Nov. 22, 1913.

— — proposal, suggested adoption of in Trinidad. *Proc. of Agric. Soc. of Trinidad*, Vol. XII (1912), p. 67.

— —, Report of Combined Court Committee.

— —, rural banks for. *I.D.A. Pamph.* No. 35.

C.

Central banks, necessity for, *Journ. Board of Agric.*, England, Vol. XV (1908), p. 411.

— —, need for in Ireland, *M.B. of Econ. & Soc. Intell.*, 4th year (1913), No. 8, p. 46.

— —. Co-operative Bank of Prussia, functions of, *M.B. of Econ. & Soc. Intell.*, 3rd year (1912), No. 10, p. 8.

Christiana Bank, Jamaica, Report on. *Journ. of Jamaica Agric. Soc.*, Vol. XV (1911), p. 555.

— — —, success of. *Journ. of Jamaica Agric. Soc.*, Vol. XV (1911), p. 170.

Co-operative credit movement, commencement of in West Indies. *W.I.B.*, Vol. VIII, p. 334.

Credit basis, occasional modification of in Germany, *M.B. of Econ. & Soc. Intell.*, 3rd year No. 10 (1912), p. 7.

— for working and improvement capital inseparable in Italy, *M.B. of Econ. & Soc. Intell.*, 4th year No. 9, p. 59.

—, instances of deserving cases of in Jamaica, *Journ. of Jamaica Agric. Soc.*, Vol. IX (1905), p. 251.

—, semi-commercial, *M. B. of Econ. & Soc. Intell.*, 3rd year (1912), No. 12, p. 99.

J.

L.

M.

P.

Q.

R.

T.

APPENDIX A.

I Assent.

J. HAYES SADLER,

Governor.

7th August, 1913.

No. 9 of 1913.

SAINT VINCENT.

AN ORDINANCE for the registration, encouragement and assistance of Agricultural Credit Societies under the Raiffeisen system.

[*21st August, 1913.*]

Be it enacted by the Governor with the advice and consent of the Legislative Council of Saint Vincent as follows —

1. This Ordinance may be cited as The Agricultural Credit Societies Ordinance, 1913. Short Title.

2. The Registrar of the Supreme Court of Judicature, hereinafter called the Registrar, shall be the Registrar of Agricultural Credit Societies under this Ordinance. Registrar of Supreme Court to be Registrar of Societies under this Ordinance.

3. All Agricultural Credit Societies wishing to obtain the benefit of this Ordinance shall be registered thereunder.

4. Any Agricultural Credit Society desiring to be registered under this Ordinance shall through the Secretary make application in writing to the Registrar and shall supply him with— Registration of Societies.

(a) The name and office or place of business of the Society,

(b) The names and addresses of the Secretary and Treasurer,

(c) The names and addresses of the Trustees,

(d) The names and addresses of all members of the Society.

5. The Treasurer of any Society desiring to be registered must be either a Minister of Religion or a Justice of the Peace or some respectable and responsible person to be approved by the Governor in Council.

6. The Secretary shall at the time of application for registration of the Society pay to the Registrar a fee of five shillings. Fee for registration.

Enquiries to be made by Registrar.

7. Before registering any Society the Registrar shall with the assistance of the committee to be appointed as hereinafter mentioned satisfy himself that the Treasurer, Secretary and Trustees of the Society are persons of good repute and character and that the Society is constituted in accordance with the rules contained in Schedule I to this Ordinance.

Minimum number of members.

8. No Society shall be registered which consists of less than twelve members.

Notice of registration to be given.

9. Upon the Registrar being satisfied as in section 7 mentioned, he shall register the Society under this Ordinance and shall send a certificate of such registration to the Secretary thereof and shall cause the fact of such registration to be notified in the Gazette.

10. (1) The Registrar shall keep a book in which shall be entered :—

(a) The name and office or place of business of each registered society,

(b) The names and addresses of the Secretary. Treasurer and Trustees thereof,

(c) The names and addresses of all members thereof.

(2) It shall be the duty of the Secretary of every Registered Society to keep the Registrar informed of any change in the office or place of business of the Society and in the names or addresses of the Secretary, Treasurer or Trustees thereof and he shall likewise notify to the Registrar the death or withdrawal of any member of the Society and the names and addresses of any new members and the Registrar shall make the alterations thereby rendered necessary in the book to be kept by him under the provisions of this Ordinance.

(3) The Secretary of any Registered Society who shall be in default for a period of one month in giving to the Registrar any information or notification required by this section shall be liable on summary conviction to a penalty not exceeding forty shillings.

Societies to be governed by rules in Schedule I.

11. Every Society registered under this Ordinance shall be governed by the Rules set out in Schedule I hereof, and the provisions of the Friendly Societies Act 1843 shall not apply to a Society so registered.

Registered Society may sue or be sued in name of Trustees.

12. A Society registered under this Ordinance may sue or be sued in the Courts of the Colony in the name of its Trustees.

Governor in Council may make loans to registered societies provided that loans in the aggregate shall not exceed £500.

13. It shall be lawful for the Governor in Council on the application of any Registered Society to advance by way of loan to such a Society a sum of money out of any surplus monies of the Colony in the hands of the Treasurer for the assistance of such Society. Provided that the total amount of loans to Societies under this Ordinance outstanding at any one time shall not exceed the sum of £500.

14. The following provisions shall apply to loans granted under this Ordinance :— Provisions as to loans.

(a) The granting or refusal of a loan shall be in the absolute discretion of the Governor in Council.

(b) The amount of the loan or loans to any one Society shall not be larger than in the proportion of Five pounds to every member of the Society.

(c) All loans shall be for not less than nine and subject to any renewal which may be permitted by the Governor in Council for not more than twelve months.

(d) The Governor in Council shall have power on being satisfied that there is good and sufficient reason therefor to call in a loan at any time, and to take all such proceedings in the courts as may be necessary to recover the full amount of that loan.

(e) All loans shall bear interest at the rate of 6% per annum payable half-yearly.

(f) All loans shall be made on the joint and several liability of the Trustees and every member of the Society.

(g) The Trustees on behalf of all the members of the Society shall enter into an agreement for the repayment of the loan and the payment of the interest thereon in the form set out in Schedule III, of this Ordinance.

(h) The Governor in Council shall have power at any time it may in his opinion appear requisite to do so and shall at least once a year instruct a Public Auditor to investigate and to report to him regarding the organization and the administration of its business of any Society registered under the provisions of this Ordinance.

15. It shall be unlawful for any Registered Society that has obtained a loan from the Governor in Council knowingly to allow any part of such loan to be applied to any purposes but those incidental to agriculture. The Trustees of any society contravening this section will be liable on summary conviction to a fine not exceeding £20. No part of a Government loan to be applied to any but purposes incidental to agriculture.

If loan already contracted from Governor in Council, Society may not borrow from private sources without consent of Governor in Council.

16. It shall be unlawful for any Registered Society which has contracted a loan or loans from the Governor in Council under the provisions of this Ordinance to borrow in addition from private sources without having first obtained the consent thereto of the Governor in Council. The Trustees of any Society contravening this section will be liable on summary conviction to a fine not exceeding £20.

17. The full details of any loan made to any Society registered under this Ordinance shall within 48 hours of the loan being made be duly recorded by the Trustees of the Society in the Registrar's Office and such record shall be open to public inspection. Any Trustee of a Society failing to carry out the provisions of this section shall be liable on summary conviction to a fine not exceeding £5.

Power to appoint Committee to assist Registrar and to make regulations.

18. The Governor in Council shall appoint a Committee to assist the Registrar in his enquiries under section 7 of this Ordinance and may make regulations as to the scope and manner of such enquiries and generally may make regulations for the carrying out of the provisions of this Ordinance. The Governor in Council shall also have power to repeal, amend or to add to the rules set out in Schedule I and to the forms set out in Schedules II, III and IV hereof.

19. The Registrar shall not be bound to give any reasons whatsoever for any refusal to register a Society under this Ordinance, but an appeal shall lie from any such refusal to the Governor in Council whose decision shall be final.

20. The Governor in Council shall have power for such reason as may appear good and sufficient to him, at any time, to cancel the registration of a Society registered under the provisions of this Ordinance. Provided that such cancellation shall not be taken to affect the joint and several liability of the Trustees and every member of the Society at the time of its dissolution, for the repayment of all outstanding loans made to the Society during its term of registration. A notification of any such cancellation shall without undue delay be published in the Government Gazette and in one at least of the local Newspapers.

Commencement

21. This Ordinance shall come into force on a day to be proclaimed by the Governor in the Gazette.

SCHEDULE I.

Rules for the government of Agricultural Credit Societies registered under this Ordinance.

I.—Name and Object of the Society.

(*a*.) The Society shall be called the "   Agricultural Credit Society." Its registered Office is   St Vincent, B.W.I.

(*b*.) Its object is to improve the situation of its members, both materially and morally, to take the necessary steps for the same, to obtain through means of the common guarantee the necessary capital for granting loans to members for the development of their lands and business, and to bring small capital into productive use.

The great underlying principle of the Society is *mutual co operation* and *mutual liability* on the part of the members, borrowing and lending being confined to the members themselves, all of whom belonging to one particular village or district being well known to each other and therefore mutually interested in the fulfilment of each others engagements and obligations on which the success of the Society entirely depends.

A great educational influence is desired to be exercised by the Society in its insistence upon good character, upon proper investments, punctuality of repayment and by the instruction it gives as to the proper value of money.

The Society rests on a christian and patriotic foundation. At meetings and in all the activities of a society, opinions and measures of a religious or political character are absolutely prohibited.

(*c*.) Loans to members shall only be made on condition that the purpose for which money is borrowed is such that there is a sufficient prospect of the repayment of same by the production or business which it will enable the borrower to effect. The object of a society is not to furnish the entire or major part of a member's working capital but to supplement it.

(*d*.) The Society shall not consist of less than 12 Members.

II.—Borrowing Powers.

The Society may receive deposits or borrow money at interest from persons other than members. The *unlimited liability* of all and every member of the Society, shall be the guarantee for the repayment of such deposits or of such Loans borrowed by the Society. (See also Rule XII.)

Should the Society however have contracted a loan or loans from the Governor-in-Council it shall not be lawful for the Society to borrow in addition from private sources without having first obtained the consent thereto of the Governor-in-Council (vide Section 16 of the Ordinance.)

III.—Membership.

(1) The Society shall consist of—

(*a*.) Original members, being householders or occupiers of land resident in the District of   , who have united together to form the Society.

(*b*.) Any person of good character, resident in the District of   , who is a householder or an occupier or owner of land in the said district, and whose liability is not already pledged by Membership in a similar association, who may be elected at a general meeting to be a member of the society on his or her application.

(2.) Any person desirous of becoming a Member must fill up and sign a Form (See Form I, Schedule II) and forward the same to the Secretary.

(3.) Any member may retire after giving at least six months notice in writing of his intention so to do to the Secretary of the Society and upon payment of all monies due by him to the Society. Any member so retiring remains liable in respect of all loans made to the Society during his membership so long as any part thereof or interest thereon remains unpaid.

(4.) The Committee of Management (vide Rule VII) shall have the power to exclude any member who may become insolvent, or be in arrears for unduly long periods with payments on share capital of interest due or of capital borrowed or who may in any serious way impair the general interest or prestige of his society. Provided however that such member, after exclusion, shall continue to be responsible for any loans made to his society during the terms of his membership.

IV.—Shares and Entrance Fees.

Every member on joining the Society must hold a share, such share shall not be less than four Shillings, the amount and time for payment of same to be determined by the General Meeting of the Members of the Society. Any person joining a Society after its formation shall in addition to the aforesaid share pay an entrance fee of two shillings. No dividend shall be payable upon such shares and entrance fees nor shall they be repaid to the Members, such shares and entrance fees being deposited as a Reserve or Guarantee Fund. (Vide Rule XIII.)

V.—Rights and Liabilities of Members.

(*a.*) Every Member of the Society shall be entitled to obtain a loan from the Society for specified and approved purposes in accordance with Rule XI. Every member shall be entitled to attend the General Meetings in which the full powers of the Society are vested to vote for the election of the Committee and certain officers and to claim all information required concerning the solvency and good management of the Society.

(*b.*) All moneys payable by a Member to the Society are deemed to be a debt due from such Member and are recoverable as such in the Civil Courts of Law.

(*c.*) If any claim on the Society made under Rule XII, which the Society is unable to satisfy, or if a Member fails to pay any Loan and the Reserve Fund is not sufficient to meet the deficiency, an equal levy shall be made on every Member for the purpose of realising the amount required. The Members of the Society are jointly and severally responsible as such for the payment of all moneys borrowed by the Society and may be sued in the Courts of Law for the same but each Member of the Society shall be liable only for Loans advanced to the Society during his membership.

(*d.*) In the event of the death of a member, the liability of his heirs, executors and administrators shall extend only to such loans as may have been contracted with the Society by him and which remain unpaid at his death, together with the interest thereon, and to such loans as may have been made to the Society during his membership.

VI.—General Meetings of Members.

(*a.*) The first Meeting of Members shall have the same powers as are herein given to the annual General Meeting.

(*b.*) An annual General Meeting of the Members of the Society shall be held in the month of May each year. At such Meeting at which three quarters of the members of a society shall form a quorum the Chairman of the Committee shall preside and shall present a Report and full Statement of accounts for the preceding year and the audited Balance Sheet which it shal be the first business of the Meeting to consider, and if satisfactory, to approve. The Chairman shall also report upon the other transactions of the Committee. The Meeting shall then decide any appeal referred to it against any decision of the Committee, brought by a member. The meeting shall then proceed to elect the Committee, Trustees, Auditors, and appoint a Treasurer and Secretary.

The meeting will also fix at each annual general meeting by resolution, the total amount of savings deposits that may be accepted, the total amount of loans that may be contracted and the maximum of the total advances that any member of the society may hold at any one time during the next year.

(*c.*) A special General Meeting of members may be called at any time by the Committee; or on receipt of a demand signed by not less than one-fourth of the members stating their reasons for calling a Special General Meeting.

(*d*) No member whatever his interest may be shall be entitled to more than one vote upon every matter submitted for consideration at any General Meeting.

VII.—The Committee.

(*a.*) The Society, at its annual General Meeting, shall elect a Committee of Management, consisting of not less than five members who shall be eligible for re-election on the expiry of their term of office. *No member of the Committee or Office Bearer shall receive salary or any other remuneration under any conditions whatever.*

(*b.*) *Duties of the Committee.*—The Committee shall elect its own Chairman, who shall preside at the General and Committee Meetings of the Society and who shall have in divisions, only one vote. The Committee shall meet as often as the necessary business of the Society shall require; three to form a quorum. It shall arrange for at least two of its members to attend in rotation upon every occasion on which the registered office is open for the transaction of the business of the Society.

(*c.*) It shall draw up a prospectus of the Society, record the names of the Committee, Trustees, Treasurer, and Secretary; the Registered offices, the day and time of Ordinary Committee meetings, fix the interest and expense to be charged for loans; and the terms and advantages offered to depositors.

It shall also have power to decide questions concerning (*a*) the purchase in common of farming requisites and (*b*) the sale in common of farm produce

(*d.*) *The procedure of Ordinary Committee Meetings.*—The Secretary shall read the Minutes of the previous meeting. The Treasurer shall then present a Statement of Accounts showing the loans outstanding, deposits on hand, and the amount of the Reserve Fund together with the number of members. This statement shall be checked and signed by the members of the Committee.

The Secretary shall then report as to the instalments or repayments due and unpaid and the action to be taken in each case will thereupon be determined.

The Secretary shall then present any applications for loans and the Committee will determine which can be granted.

Any special questions submitted for the consideration of the Committee shall then be discussed.

Special Duties of the Committee.' The Committee shall satisfy itself that all rules have been complied with; *consider whether there has been any alterations in the status of any borrower or his sureties, if any, which would justify special action being taken for the termination of any Loan; appoint any person they think desirable in order to ascertain whether all Loans granted are being used for the purposes for which they were obtained or are intended.*

The Committee shall fix the rate of interest for all Loans and have power to alter the same after giving 3 months notice to the borrower.

The Committee of Management shall direct the Secretary to supply all Returns required by the Registrar.

It shall also be the duty of the Committee of Management to keep open at all times, a copy of the last annual balance sheet of the Society for the time being together with the Report of the Auditors, for the inspection of the Members of the Society, or of the Registrar or of any person appointed by him for that purpose.

Vacancies—Vacancies occurring on the Committee through death, resignation or removal, shall be filled at a Special General Meeting of the Society which shall forthwith be summoned to elect a member to fill the vacancy. The Member so elected shall remain in office until the succeeding annual General Meeting and will then be eligible for re-election.

VIII.—The Trustees.

The General Meeting shall elect two Trustees to hold the property of the Society. The Trustees shall place any money belonging to the Society not required for Loans on deposit in the Government Savings Bank or in any Joint Stock Bank. No Trustee shall receive any remuneration for services rendered.

Each Trustee shall give security in his own personal bond and in one solvent surety for the funds of the Society in the possession of the Trustees, in such sum as the Committee of Management may decide is reasonable.

IX.—The Treasurer.

The annual General Meeting shall appoint a Treasurer who shall be either a Minister of Religion or a Justice of the Peace or some respectable and responsible person approved by the Governor in Council and who shall by virtue of his office be a Member of the Committee. He shall receive from the Secretary all monies paid to him on behalf of the Society. When the sum deposited with the Treasurer exceeds an amount fixed by the Committee such excess shall be paid to the Trustees for investment in the Government Savings Bank or any Joint Stock Bank (See Rule VIII). If the Treasurer wishes to

resign the position, a Special General Meeting of Members shall be called to elect another Treasurer. The Treasurer may also hold the position of Secretary. The office of Treasurer shall be purely an honorary one and he may or may not be a member of the Society.

The Treasurer shall give security in his own personal bond and in one solvent surety for the funds of the society in his possession, in such sum as the committee of management may decide is reasonable.

X. THE SECRETARY.

The annual General Meeting shall appoint a Secretary. The duties of the Secretary shall be.—(*a*) To attend all meetings of the General Society or Committee of Management. (*b*) To keep a Register of names and addresses of all Members. (*c*) To supply Forms, Balance Sheets or other particulars required by Members. (*d*) To record Minutes of Meetings and the whole of the transactions of the Society in the books provided. (*e*) To conduct all correspondence. (*f*) To receive and deposit with the Treasurer all monies received on behalf of the Society. (*g*) To receive all applications for Loans or notice of withdrawals of Deposits and to bring the same before the Committee. (*h*) To prepare receipts and other documents in the form arranged for the signature of borrowers prior to their taking the Loans sanctioned. (*i*) To pay to members or others amounts authorized to be paid by the Committee.

In addition to these general duties, the Secretary shall prepare the annual Financial Return and Balance Sheet and shall attend upon the Auditors when making the audit, producing for their inspection vouchers for all payments which have been made on behalf of the Society.

The Secretary shall be an Honorary Officer, and may be the Treasurer also in which latter case he may or may not be a member of the Society.

The Committee may immediately suspend the Secretary for any irregularity in the performance of his duties, and appoint a substitute. The Secretary shall have the right to appeal to a Special General Meeting.

The duties of the Secretary may be shared with certain members of the Committee, if so approved by the Committee, or the Committee may sanction the employment of a clerical assistant for some of the stated work and in this case the expenses of such assistant shall be defrayed from the funds of the Society as the Committee may determine, but such assistant shall not be a member of the Society, nor entitled to borrow any of the Funds of the Society.

The Secretary shall give security in his own personal bond and in one solvent surety in such sum as the Committee of Management may decide is reasonable, for the funds of the Society which will in the course of business pass through his hands.

XI.—LOANS.

(*a*.) Loans, when approved by the Committee, shall be granted to members who are able to obtain either one or two sureties as may be approved by the Committee or who can give such security as the Committee may deem sufficient. No member who is in possession of money lent to him by the Society shall be accepted as surety for another member requiring a loan unless the members of the Committee are unanimous that it is safe to accept him. The application shall be forwarded to the Secretary and considered by the Committee.

(*b*). Members who desire to obtain a Loan shall fill up a form (see Form II, Schedule II) stating the amount required, the object for which it is required, the term for which it is asked, whether it is desired to repay the Loan by instalments, with the security offered.

(*c*.) If the Committee are satisfied with the trustworthiness of the the applicant, the sufficiency of the security offered, the profitableness by productiveness or saving which the use of the loan may effect, and if they have sufficient funds under their control they may sanction the loan.

(*d*.) No loan shall be granted for a period exceeding one year, or to any person who is not a registered member of the Society.

(*e*.) If the Committee decide that the loan cannot be granted from lack of funds or aught else, or if they think proper to postpone the consideration of any application, the Secretary shall notify the applicant to that effect.

(*f.*) If the Loan is repayable by instalments, prompt payment must be made and no excuse accepted for non-payment.

Any want of faithful compliance shall render the borrower liable to have his full Loan immediately recalled. Where sickness or other sufficient cause is duly notified to the Secretary before an instalment is due, the Committee may extend the time for repayment of an instalment.

(*g.*) The interest to be charged on Loans shall in no case exceed 8% per annum. The interest shall be payable at the time the Committee determine but in no case later than the same date as the loan is repayable.

(*h.*) When a loan is sanctioned, the borrower should be notified to that effect by the Secretary and if the borrower does not consent to take the Loan on the terms offered by the Committee within one week from the date upon which assent is given, the Committee shall not be held bound to complete the Loan. If the borrower consents to accept the terms offered, then before the amount be advanced the borrower and his sureties, if any, shall execute a promissory note or a declaration as to possession of effects free from encumbrance or any other document which the Committee may consider necessary, and the borrower shall also enter into an agreement as to the terms of repayment (see Form III, Schedule II.)

(*i.*) If the Loan be repayable by instalments the borrower shall be supplied with a card (see Form IV, Schedule II) or book upon or in which shall be stated the amount and the terms of advance and upon or in which the instalments when repaid shall be entered and initialled by the official to whom the money is paid.

(*j.*) If any member shall be found to have misapplied a loan, the Committee shall have power to recall the Loan immediately.

(*k.*) If a member of the Committee be an applicant for a Loan he must withdraw from the Meeting of the Committee while such application is under consideration. No Loan shall be granted to any member whose credit is pledged in any other Agricultural Credit Society in another district.

(*l.*) In the case of loans being sanctioned for the purchase of live stock, such stock must be vaccinated against anthrax.

XII.—Borrowing Powers.

The Society shall have power to borrow capital on the security of all the ordinary Members, jointly and severally, but whenever such action is taken, the unanimous decision of all the Members must be obtained at a General Meeting of the Society inasmuch as responsibility of repayment descends to each and every member to the last and every member is liable to be sued for repayment of the same.

Should the Society however have contracted a loan or loans from the Governor in Council, it shall not be lawful for the Society to borrow in addition from private sources without having first obtained the consent thereto of the Governor in Council. (*Vide* Section 16 of the Ordinance).

XIII.—Reserve Fund and Expenses of Management.

A Reserve Fund shall be formed to serve as cover for any loss as shown by the balance sheet. Such Reserve Fund shall be formed from shares and entrance fees and by turning over to it at least ten per cent. of the annual net profits. The Reserve Fund should be brought up to the amount of 20 per cent of the total working capital as shown in the balance sheet but as a minimum to the total amount of the share and entrance fee capital.

In the event of its being necessary to draw upon the Reserve Fund it should as soon as possible again be brought up to the above limit.

In no case shall the Reserve Fund be divided and should the Society be dissolved it shall be devoted to some useful public purpose in the district or village in which the Society operated, and determined upon by the meeting at which the dissolution of the Society takes place.

Any sums to the credit of the Reserve Fund shall be placed on deposit by the Trustees in the Government Savings Bank or any Joint Stock Bank.

No profit, bonus or dividend of any kind shall be divided among the Members.

If the income derived in any one year from sources other than shares and entrance fees prove insufficient to meet the expenses of management, then the annual general meeting may order a levy on the members or vote such sum as it may think desirable from the Reserve Fund to meet such deficiency subject to the above limitation.

XIV.—Accounts and Book-Keeping.

(*a.*) In the books of the Society provisions shall be made for keeping :

1. The minutes of all Meetings.
2. A Register of Names and addresses of all Members.
3. Particulars of applications for Loans, and dates on which repayments were made.
4. A Cash book in which all amounts received or paid for any purpose shall be entered.
5. Accounts as required by the Auditors, in which shall be posted all entries from the Cash Book.

(*b.*) An annual Financial Return shall be prepared each year showing Receipts and Expenditure for the preceding year ; and a Balance Sheet drawn up showing the Funds and Effects of the Society and its liabilities to date.

(*c.*) The books and accounts shall be open to the inspection of any Member of the Society, at all times of Meeting, or when the Registered Office is open for the transaction of the Society's business.

XV.—Audit of Accounts.

(*a.*) The Committee of Management shall once at least in every year submit the accounts, together with a general statement of the same, and all necessary vouchers, books, documents, cash in hand or other goods belonging to the society for audit, to two or more persons appointed as auditors by the members at the Annual General Meeting each year, and in addition shall give all facilities for inspection and investigation by a Public Auditor as provided for by section 14 (*h*) of this Ordinance and shall lay before every such meeting a balance sheet showing the receipts and expenditure, funds and effects of the Society, together with a statement of the affairs of the Society since the last ordinary meeting, and of their then condition. Such auditors shall have access to all the books and accounts of the Society, and shall examine every balance sheet and Annual Return of the receipts and expenditure, funds and effects of the Society, and shall verify the same with the accounts and vouchers relating thereto, and shall either sign the same as found by them to be correct, duly vouched, and in accordance with law, or shall specially report to the meeting of the Society before which the same is laid, in what respects they find it incorrect, unvouched or not in accordance with law.

(*b.*) A copy of the Annual Balance Sheet of the Society, duly certified by the Auditors shall be forwarded to the Registrar as soon as possible after the completion of the same.

XVI.—Settlement of disputes.

Any dispute arising between a member or person claiming through a member, or under the rules, and the Society, or the Committee, or any officer thereof, may be brought before a General Meeting of the members, whose decision shall be final.

XVII.—Dissolution of the Society.

The Society may at any time be dissolved by the consent of five-sixths of the members, testified by their signatures to an instrument of dissolution.

SCHEDULE II.

FORM I.

FORM OF APPLICATION FOR MEMBERSHIP.

To the

AGRICULTURAL CREDIT SOCIETY.

19 .

I, the undersigned, hereby apply to be admitted a member of the above-named Society, and, if accepted, agree to be bound by and observe all the Rules and Regulations of the Society.

Signature of Applicant
(in full.)
Occupation
Address

Admitted a member of the above-named Society this day of 19

Chairman.
Secretary.

FORM II.

APPLICATION FOR LOAN.

I being a member of the Agricultural Credit Society hereby make application for a loan of £ subject to the rules of the Society.

1. *The loan is to be repayable on the day of 19 . with interest at % *or* The loan with interest thereon at % to be repayable by instalments of £ on the day of and the day of

2. The purpose for which I require the loan is

3. The Security I am prepared to offer is

Signature
Address
Occupation

Date 19

* *Cross out the part of this paragraph inapplicable.*

NOTICE APPROVING APPLICATION FOR LOAN.

To Mr.

NOTICE IS HEREBY GIVEN that the Committee of the AGRICULTURAL CREDIT SOCIETY, have decided to grant you a loan of Pounds shillings and pence upon the terms and conditions specified in your application of the day of , 19 .

For THE AGRICULTURAL CREDIT SOCIETY.

Chairman.
Secretary.
19

Form III.

AGREEMENT FOR LOAN FOR A TERM.

An Agreement made this day of One thousand nine hundred and Between THE AGRICULTURAL CREDIT SOCIETY being a Society duly registered under the St. Vincent Agricultural Credit Societies Ordinance 1913 and having its Registered Office at in the Island of hereinafter called "the Society" of the one part and of hereinafter called "the Borrower" of the other part

Witnesseth that in consideration of the sum of pounds this day lent to the Borrower (the receipt whereof is hereby acknowledged) he the said borrower hereby agrees –

(1) * That he will repay the said sum of with interest at the rate of per cent. per annum on the day of next, *or* that he will repay the said sum with interest thereon at % by instalments of £ on the day of 19 , and the day of 19 .

(2) That he will employ the said sum of pounds for the purpose of and will furnish the Society or its representatives with such proof thereof as they may reasonably require.

(3) That he will be bound by and observe all the Rules and Regulations of the Society for the time being in force.

(4) That in the event of the non-performance or non-observance of all or any of the terms and conditions on the part of the Borrower herein contained and hereby agreed to be performed and observed the said sum of pounds shillings and pence or such part thereof as shall remain unpaid with interest as aforesaid shall immediately become due and payable and if not paid upon demand shall be recoverable from the Borrower as a debt in the Law Courts of the Island where the office of the Society is situate.

As Witness the hands of the parties the day and year first above written.

Signature of borrower
Address
Occupation
Witness to signature of borrower
Signature of Secretary at the direction of Committee

* *Cross out the part of this paragraph inapplicable.*

The undersigned of and of bind $\frac{\text{themselves}}{\text{himself}}$ as $\frac{\text{Sureties}}{\text{Surety}}$ for the abovenamed debt not only for interest but as joint and several debtors of the Agricultural Credit Society until the complete redemption of the same, also for any period of extension and expressly declare that $\frac{\text{they}}{\text{he}}$ renounce any plea by which $\frac{\text{they}}{\text{he}}$ may void $\frac{\text{their}}{\text{his}}$ liability.

witness signature.

Date witness signature.

Seen and noted for payment according to the decision of the Committee of Management this day of 191

Chairman.

FORM IV.

LOAN REPAYMENT CARD.

Agricultural Credit Society.

LOAN REPAYMENT CARD.

REGISTERED OFFICE.

HOURS.

OFFICERS.

Date.	Amount.	Secretary's Initials.
Brought forward		

Name of Borrower.
Address.
Amount. £ Date granted.
Term of Loan.
How to be repaid
Date when to be completed. 19

Date.	Amount.	Secretary's Initials.
Carried forward		

OBJECTS OF THE SOCIETY.

To assist members by loans of money at a moderate rate of interest and to raise money for this purpose on the combined security of all the Members of the Society.

CONDITIONS OF BORROWING.

That the borrowers shall be persons of good character.

That they shall live in the area in which the Society operates.

That they shall apply the money borrowed for a specific purpose sanctioned by the Committee.

That they shall give such security as the Committee may consider necessary.

That they shall be bound by the Rules and Regulations of the Society.

SCHEDULE III.

Agreement for repayment of loan made to a Society.

WHEREAS for the purpose of assisting an Agricultural Credit Society in the Colony of St. Vincent known as the Agricultural Credit Society which Society has been duly registered under the provisions of "The Agricultural Credit Societies Ordinance, 1913". (hereinafter called the lender), has agreed to advance the sum of to the Trustees and Members of the Society by way of loan upon the joint and several liability of the said Trustees and Members.

Now this agreement witnesseth that in consideration of a loan of made to of and of , the Trustees of the said Society, the receipt of which the said Trustees do hereby acknowledge the said and as such

Trustees acting on behalf of themselves and all the Members of the said Society do hereby jointly and severally agree that they will on the day of 19 , repay to the lender the sum of with interest thereon at per centum per annum

Signed on behalf of the Agricultural Credit Society.

} Trustees.

Witness
Witness

SCHEDULE IV.

Articles of Association of the Agricultural Credit Society registered under the Agricultural Credit Societies Ordinance, 1913, on the day of 19 .

We the undersigned agree to become members of the Agricultural Credit Society and by virtue of our Signatures hereto appended we agree to be bound and to abide by all rules that have been made, or that may in the future be passed by the Governor in Council, for the government of Agricultural Credit Societies registered under the Agricultural Credit Societies Ordinance, 1913, or under any Ordinance amending the same.

We further hereby acknowledge our joint individual unlimited liability for all loans contracted on behalf of the Society by the Trustees wich the consent of a general meeting of the Society and also for all deposits that may be made in accordance with the rules referred to above.

Date of signing Articles.	*Witness to Signature.*	*Signature of Member.*

Note.—(1) Each member must sign two copies of this document.
(2) One copy to be lodged with the Reigstrar and once copy in the offices of the Society.
(3) Any new member joining must sign both copies.
(4) A copy of the rules must be attached to each copy of the articles of association.

Passed the Legislative Council the 10th day of June 1913.

S. C. CONNELL,
Acting Clerk of Councils.

This Ordinance was returned to the Council by the Governor for Amendment under Standing Order No. 27 A., and was recommitted and passed the 29th day of July, 1913.

S. C. CONNELL,
Acting Clerk of Councils.

Published in the Government Gazette this 21st day of August 1913.

V. F. DRAYTON,
Clerk of Councils.

Regulations made by the Governor in Council under section 18 of "The Agricultural Credit Societies Ordinance, 1913."

(Gazetted 21st August 1913.)

1. Before registering any Agricultural Credit Society under section 9 of the Agricultural Credit Societies Ordinance, the Registrar shall with the assistance of the Committee appointed by the Governor in Council under the authority of section 18 satisfy himself on the following points :--

(*a*) That the Society making application to be registered has been constituted in accordance with the rules contained in Schedule I or in any amendments thereof and that all the members of the Society have signed an agreement in terms of Schedule IV to the Ordinance.

(*b*) That the application for Registration submitted by the Society complies strictly with sections 4 and 8 of the Ordinance.

(*c*) That the persons whose names are submitted as Trustees of the Society are fit and proper persons to act as such.

(*d*) That the person whose name is submitted as Secretary has been duly elected with the general approval of the members at a general meeting of the Society and that he is a fit and proper person to hold the position.

(*e*) That each member of the Society is the possessor of one paid up share in the Society in a sum of not less than four shillings, and that each holds a good character and has a reputation for honesty, thrift, sobriety and diligence and is a fit and proper person to be a member of the Society.

(*f*) That, in the event of the Treasurer not being a Minister of Religion or a Justice of the Peace, the person selected for that position, has in accordance with the provisions of section 5 of the Ordinance, been approved by the Governor in Council.

2. In order to assist the Registrar and his Committee in coming to a conclusion on the foregoing matters, the Secretary of any Society in making application for the registration of the Society shall supply the following particulars in addition to the particulars required to be given under section 4 of the Ordinance. And all such particulars when supplied shall be regarded as private and confidential and shall not in any way be made public, except when necessary to the Governor in Council or with the consent of the Trustees of a Society to any person proposing to make a loan to such Society :—

(*a*) The business or calling of the Secretary and Treasurer and the amount of security that it is proposed that each should give.

(*b*) The business or calling of each of the two Trustees and the amount of security that it is proposed that each should give.

(*c*) The business or calling of each member of the Society and showing whether each is an owner of land or a renter of land and the amount of land owned or rented in each case and whether coastal or mountain land.

The above particulars as well as those required by section 4 of the Ordinance, shall be supplied on a Form appended to be known as Form V.

3. The Registrar with his Committee shall in all cases be entitled to demand evidence of, and to inspect, the nature of the Securities and satisfy himself of the solvency of the Sureties, submitted for the due performance of the duties of those holding the offices of Treasurer, Secretary or Trustee of a Society.

4. The Registrar assisted by his Committee shall in addition to the above advise and make recommendations in regard to any other matter relating to the carrying out of the provisions of the Ordinance, that may be referred to him by the Governor.

5 These Regulations shall come into force upon the same day as the Agricultural Credit Societies Ordinance, 1913, is proclaimed.

Form V.

Application for the Registration of the Agricultural Credit Society formed under the Agricultural Credit Societies Ordinance, 1913.

To the Registrar at the Court House, Kingstown.

I of do declare that I was duly elected Secretary of the Agricultural Credit Society at a general meeting of the said society held on the day of 19 , and that I have been authorized by the said society at a general meeting, to make application for the registration of the society under section 9 of the said Ordinance.

2. I enclose order for five shillings as registration fee.

I enclose the signed Articles of Association of the society. (Schedule IV.)

4. I append also the particulars required by section 4 of the said Ordinance and by Regulation 2 of the Regulations passed by the Governor in Council under section 18 of the Ordinance.

Particulars of the Agricultural Credit Society

1. Office or place of business of the Society.

2. Name and address of Secretary.

3. Business or calling of Secretary.

4. Amount of security bond to be given by Secretary.

5 Name and address of Secretary's Surety.

6. Name and address of Treasurer.

7. Business or calling of Treasurer.

8. Amount of security bond to be given by Treasurer.

9. Name and address of Treasurer's Surety.

	First Trustee.	Second Trustee.
Name and address of		
Business or calling of		
Amount of security bond to be given by		
Name and address of surety of		

Members name.	Members address.	Business or calling.	Whether owner or renter of land.	Amount of land owned or rented.	Whether coastal or mountain land.	Remarks.
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

And I declare the above particulars to be true and accurate in every respect, to the best of my knowledge and belief.

Signature

Secretary,
Agricultural Credit Society.

1. Witness [1]

2. Witness [1]

Dated 19 .

[1] The Treasurer and one Trustee shall witness the signature of the Secretary.

Made by the Governor in Council this 21st day of August, 1913.

V. F. DRAYTON,
Clerk of Councils.

Amendment of the Rules forming Schedule 1 to "The Agricultural Credit Societies Ordinance, 1913," for the government of Agricultural Credit Societies Registered under that Ordinance.

(Gazetted 16th October, 1913.)

1. The second paragraph of Rule VI (*b*) commencing with the words "The meeting" down to the words "next year" is hereby repealed and the following paragraph is substituted therefor :—

"The members will also fix at each annual general meeting, "by resolution, the total amount of savings deposits that may "be accepted, the total amount of loans that may be contract-"ed, the maximum of the total advances that any member of "the Society may hold at any one time during the ensuing year, "the rate at which the Secretary may be remunerated and "when necessary the amount to be levied on each member in "respect to such remuneration."

2. Rule VII (*a*) is hereby repealed and the following paragraph substituted therefor—

"(*a*) The Society, at its annual general meeting, shall elect "a Committee of Management, consisting of not fewer than "five members, who shall be eligible for re-election on the ex-"piry of their term of office. No member of the Committee nor "any Office Bearer, except the Secretary, shall receive salary "or any other remuneration under any conditions whatever."

3. Rule X is hereby amended by the addition of the following paragraph --

"The Secretary may be remunerated at a rate to be deter-"mined by the members at a general meeting. The funds for "payment of such remuneration may if necessary with the "consent of a general meeting be obtained by equal levy on all "the members of the Society."

4. The appended Form VI being a form of Bond to be used for the Treasurer, Trustees and Secretary of a Society, shall be added to Schedule II of the Rules.

THE AGRICULTURAL CREDIT SOCIETIES ORDINANCE, 1913. FORM VI.

SAINT VINCENT.

Know all men by these presents that We
of
of the
Agricultural Credit Society, established in accordance with the provisions of the Agricultural Credit Societies Ordinance, 1913, at in the Parish of in the Island of and
of
(as surety on behalf of the said
) are jointly and severally held and firmly bound to the present Administrator of this Colony, his successors and assigns, in the sum of
to be paid to the said as such Administrator for the time being,

or to his successor for the time being, or to his certain attorney, for which payment, well and truly to be made, we jointly and severally bind ourselves, and each of us by himself, our and each of our heirs, executors, and administrators, firmly by these presents, sealed with our seals.

Dated the day of in the year of our Lord one thousand nine hundred and

WHEREAS the above-bounden hath been duly appointed of the said Society established as aforesaid, and he, together with the above-bounden as his surety, have entered into the above-written Bond, subject to the conditions hereinafter contained. Now, THEREFORE, the Condition of the above-written Bond is such that if the said shall and do justly and faithfully execute his office of of the said Society established as aforesaid and shall and do render a just and true account of all moneys received and paid by him, and shall and do pay over all the moneys remaining in his hands, and assign and transfer or deliver all securities and effects, books, papers, and property of or belonging to the said Society, in his hands or custody, to such person or persons as the said Society shall appoint, according to the Rules of the said Society, together with the proper or legal receipts or vouchers for such payments and likewise shall and do in all respects well and truly and faithfully perform and fulfil his office of to the said Society, according to the Rules thereof, then the above-written Bond shall be void and of none effect, otherwise shall be and remain in full force and virtue.

[Seal]
[Seal

Signed sealed and delivered by the above-named
in the presence of

....	....
Name.	*Name.*
....	....
Occupation.	*Occupation.*
Residence	*Residence.*

Signed sealed and delivered by the above named
in the presence of

....	....
Name.	*Name.*
....	....
Occupation.	*Occupation.*
....	....
Residence.	*Residence.*

Made by the Governor in Council this 14th day of October, 1913.

V. F. DRAYTON,
Clerk of Councils

Further amendment of the Rules forming Schedule 1 to "The Agricultural Credit Societies Ordinance, 1913," for the government of Agricultural Credit Societies registered under the said Ordinance.

(Gazetted 13th November, 1913.)

1. Rule V is hereby amended by the addition of the following words at the end of sub-section (*d*) thereof:—

"If a member dies intestate without any legal representative "and no person has obtained letters of administration within a "reasonable time the Trustees shall have power to apply for "letters of administration as an ordinary creditor would be "entitled to do."

2. The whole of the third paragraph of Rule X from the words "The Secretary" down to the words "member of the Society" is hereby repealed and the following paragraph substituted therefor:—

"The Secretary may be the Treasurer also and he may or "may not be a member of the Society."

3. Rule XI (*f*) is hereby amended by the insertion of the words "or otherwise" after the word "instalments" in the first line thereof.

Made by the Governor in Council this 11th day of November, 1913.

W. S. BATTEN-POOL,
Acting Clerk of Councils.

NOTE... The first amendment of the principal rules was made on the 14th October, 1913 (Vide Gazette of 16th October, 1913).

REPORT ON THE AGRICULTURAL CREDIT SOCIETIES OF ST. VINCENT.

BY ROBERT M. ANDERSON.
Secretary of the Administration Committee.

The Hon. C. Gideon Murray, the Administrator of the colony, having recognized the necessity for pecuniary assistance to the peasant proprietors, resolved to provide them with facilities for obtaining money for the development of their lands and business through means of a common guarantee or a system of mutual liability for loans made to persons collectively forming themselves into Agricultural Credit Societies. Accordingly, in the year 1910 an attempt was made to establish experimental Agricultural Credit Societies on the Raiffeisen system in accordance with certain model rules which were circulated. Two societies were formed--one at Questelles and the other at Lowmans (near Kingstown).

The result of this venture being satisfactory, the Administrator proceeded to perfect his scheme designed to provide agencies and sources whereby the peasantry would be capable of negotiating loans for short periods under advantageous terms instead of at the prevailing exorbitant interest running sometimes as high as 100 to 120 per cent. per annum. In June 1913, an Ordinance was submitted to the Legislature for the registration, encouragement, and assistance of Agricultural Credit Societies under the Raiffeisen system. It was passed on the 29th day of July 1913 and was brought into operation on the 4th day of September of the same year.

A memorandum containing complete particulars for the guidance of persons desiring to form Agricultural Credit Societies was distributed gratuitously in the month of August 1913. Appended to it were certain necessary forms including model Articles of Association and a form of application for registration of a society.

The Registrar of the Supreme Court of Judicature is constituted the Registrar of Agricultural Credit Societies by the Ordinance, in which provision is also made for the appointment of a committee to assist him in matters relating to such societies.

The members of the committee are :--

The Registrar--Hon. R. E. Noble, Chairman.

The Chief of Police--Major J. A. Meldon (recently promoted to Grenada).

The Superintendent of Crown Lands--Mr. J. Landreth Smith.

The Agricultural Superintendent--Mr. W. N. Sands.

The Secretary is the Chief Clerk in the Registrar's Office--Mr. Robert M. Anderson.

In view of their official duties all the officers of this committee are in touch with the peasantry. The Administrator's motive therefore for the selection of these officers to be members of the committee needs no explanation.

The duties assigned to the committee and embodied in regulations are, mainly, to ascertain before registering a society that—the society is composed of persons known to be honest, industrious and thrifty, and that the persons whose names are submitted for the various offices and their sureties possess the required qualifications; also to advise and to make recommendations concerning any other matter for carrying into effect the provisions of the Ordinance.

Six societies were registered on the 24th day of November 1913 (a little over two months after the passing of the Ordinance), comprising a total number of 135 members. These societies are located in different parts of the colony. A short description of each of these registered societies, their membership and location may here prove of interest.

(1) The Georgetown Agricultural Credit Society consists of fourteen members. The Rev. A. J. Cocks is the Treasurer and Secretary, the Trustees are Messrs. John Samuel Dick and John Pierre Louis and the Chairman is Mr. Edward Gatherer, the last three of whom are peasant proprietors. All the lands in the occupation of these members are situated toward the mountains where they cultivate arrowroot, cacao, ground provisions, cassava and sugar-cane. This town is on the eastern side of the island, 22 miles from Kingstown.

(2) The society at Union has nineteen members. The Rev. A. J. Cocks is also the Treasurer; Mr. Jonathan L. Adams, a schoolmaster, is the Secretary; Mr. R. C. A. Morris, a shopkeeper and peasant proprietor, is the Chairman and a Trustee, and Mr. James P. Smart, a planter and peasant proprietor, is the other Trustee. On their lands, all of which are toward the mountain, they cultivate arrowroot, cacao, cassava, ground provisions and sugar-cane. This village is 15 miles from Kingstown on the eastern side of the island.

(3) At the village of Stubbs, also on the eastern side of the island, 9 miles from Kingstown, the Agricultural Credit Society consists of eighteen members. The Treasurer and Chairman is the Rev. E. A. Pitt; the Secretary is Mr. H. E. A. Daisley, a schoolmaster; the Trustees are Messrs. Charles Huggins and Shadrach Toussaint. On their mountain and low lands they cultivate cotton, arrowroot, ground-nuts and ground provisions.

(4) The society at Lowmans, which place is 2 miles from Kingstown in a northern direction, has struggled along since the first attempt in 1910 to which I have alluded. It has been re-organized to comply with the Ordinance and has nineteen members. The Governor-in-Council approved the appointment of Mr. David Gumbs as Treasurer. He is a well-respected peasant proprietor.

Mr. Joseph Ash, Crown Lands Ranger, is the Secretary; Messrs. Jonathan Charles and Samuel Williams are the Trustees, and Mr. Walter Scott is the Chairman. All possess small parcels of land toward the mountain and lower elevations on which they grow cotton, cassava, arrowroot and ground provisions.

(5) The Agricultural Credit Society at Troumaca has thirty-nine members—a larger number than any other similar society. The Treasurer is Mr. Richard Anthony, a thrifty and highly esteemed peasant proprietor for whose appointment the approval of the Governor-in-Council was obtained. Mr. Jeremiah Providence is the Secretary and Messrs. Jonathan Richards and Samuel Lawrence are the Trustees. They are all in possession of small holdings. The Chairman, Mr. T. W. Clarke, a schoolmaster, has done good service in the neighbourhood in this and in other connexions. The Post Office and telephone for the benefit of the people are at his residence; and for the cotton competition of this year he was awarded the highest prize. Troumaca is a fertile village on a gradual slope 18 miles from Kingstown in a north-western direction. It was once famous for ground provisions and live stock, most of which were exported. Cotton is principally grown on the low lands at the present time; small quantities of arrowroot, cassava, and sugar-cane are also produced.

(6) The society at Chateaubelair has twenty-six members. The Rev. C. G. Errey is the Treasurer; Mr. D. A. Dennie, a schoolmaster, is the Secretary; Messrs. Joseph Hamilton and Emmanuel Charles, peasant proprietors, are the Trustees, and Mr. Jonathan G. Morgan, a shopkeeper and proprietor of 90 acres of land is the Chairman. All the members own mountain lands, two only possess coastal lands and two both coastal and mountain lands. Cacao is the principal product; sugar-cane and cassava are grown to a limited extent. This town is 21 miles from Kingstown in a north-western direction.

In the capacity of Secretary to the committee appointed by His Honour the Administrator I have attended a few of the preliminary meetings of societies in course of formation. It afforded me pleasure to participate in the deliberations, and especially to listen to the gratitude earnestly expressed for the extended solicitude of the Government toward the welfare of the people. This also gave me the opportunity to confirm my opinion, that the Registrar or other Government Officer authorized to inspect the books, etc., of the society could render valuable assistance by discussing with the members any problem they need help to solve. On such occasions he should endeavour to impress upon them the essential importance of frugality to enable them to fulfil their obligations and ensure their continued usefulness, as well as solvency. Their success will thereby be greatly enhanced and additional confidence in the Government inspired by this continued interest in their affairs.

My experience in regard to the organization and working of societies, composed chiefly of natives in the humbler stations of life, proved of great value to me. For example, a man of this class who knows his neighbour to be improvident and perhaps dishonest is in most cases very reluctant to object to his membership. Here, therefore, is a proof of the importance of the investigations of the character of members by the Registrar's committee referred to earlier in this paper. In addressing them I suggested the taking of votes by ballot or on pieces of folded paper marked 'yes' or 'no', and I urged the adoption of a manly attitude, illustrating how an indifferent and extravagant friend or brother who fails because he does not deserve to succeed, could make it possible for a careful person to be dispossessed of that for which he laboured hard and which he intended to pass to his children or relations. I spoke also on subjects not connected with Agricultural Credit Societies. In one place I admonished them for their unwillingness to repair and maintain pathways to their plots of land, explaining, among other things, that although other persons may not escape infection of a disease arising from their insanitary habits, those in their village would certainly suffer first and fatally, in all probability. A few members responded, regretfully admitted their errors, promised to correct them and to advise others accordingly. It has since been reported to me that these roads have been cleaned and repaired and a few names removed from those of persons who are endeavouring to establish an Agricultural Credit Society in that particular village.

The mutual co-operation and mutual liability are thoroughly understood; questions have arisen and each point made clear. They now have an entire grasp of every detail and are striving to the utmost to attain those objects for which the society is intended. If they be fortunate to achieve the share of merit proportionate to their honesty of purpose and their exertions in should result in a far more prosperous condition than any in which they have ever been.

In a few of the societies the more intelligent members are preparing to execute the plans they long ago conceived for their advancement but which were rendered impracticable by lack of funds. Among them is the manufacturing of their produce themselves rather than submitting to the inconvenience now experienced by being forced to convey their produce to the nearest estate for manufacture and the excessive charges which consequently diminish their profits. There is for instance a great demand locally for syrup and muscovado sugar. In fact, traders from the Grenadines have not infrequently taken back their money because they failed to obtain syrup.

To what extent the societies will succeed depends principally on the patronage of depositors and investors: in this respect it is unfortunate but nevertheless true that in St. Vincent there are few who would be willing to support this project of the Government to a considerable degree. The Provident Societies at various parts of the island, however, may not be unwilling to invest their surplus funds with the Agricultural Credit Societies and in that way extend their usefulness in another sphere. The expediency of this proposal has already commended itself to

several persons who are members of both the Provident and Agricultural Credit Societies in the same parish and it is confidently believed that the desired object will be accomplished. The Colonial Bank is also being approached with a view to ascertaining whether that bank will not give the same facilities for loans to Agricultural Credit Societies in St. Vincent as some twenty large banks in England are granting to similar Agricultural Credit Societies in England.

The thriftless and those addicted to unprincipled habits are being scrutinized and excluded as far as possible from membership, but admitting that a few of them become members, the difficulties to be encountered thereby should be regarded as transient, for they most probably will disappear like the ripened flower that falls when the fruit matures.

Applications for Government loans from the registered societies at Georgetown, Union, Chateaubelair, and Troumaca, representing a total sum of £294 have been recommended to the Governor-in-Council by the committee appointed under the provisions of the Ordinance, and this amount will probably be loaned to these societies during the month of January 1914. For the present the Governor-in-Council has power under the Ordinance to loan to registered societies a sum aggregating £500. It is sincerely hoped that private enterprise will supply such balance as may be required, and that Agricultural Credit Societies on the Raiffeisen system will prove as stable an investment and as successful in St. Vincent as they have shown themselves to be in every other country where they have been adopted.

[Pages 1–79, issued 1st April, 1914].

A STUDY OF THE RESULTS OF THE MANURIAL EXPERIMENTS WITH CACAO CONDUCTED AT THE BOTANIC STATION, DOMINICA.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S.,

Government Chemist and Superintendent of Agriculture for the Leeward Islands.

During the past eleven years manurial experiments with cacao have been systematically conducted on plots of mature cacao trees situated in the Botanic Gardens, Dominica.

Detailed accounts of the results obtained from these trials have been included in the Annual Reports on the Botanic and Experiment Stations, Dominica; while reviews embodying the more salient features have appeared from time to time in the *West Indian Bulletin.*

The series embodies trials with a variety of manurial treatments, but the essential feature has been preserved throughout, that each year the same manure has been applied to the same plots.

At the present time, therefore, each experimental unit embodies the outcome of a number of years' continuous manurial treatment on the same lines, and study of the conditions obtaining thereon both in respect of the cacao trees themselves and also of the soil of the plots becomes a matter of considerable interest.

The experiments were originally laid out in the year 1901-2 by Dr. Watts, and Mr. J. Jones, Curator of the Botanic Station, and comprised five plots varying in area from 0·28 to 0·37 acre. In 1907 four additional plots were laid out under the same direction in order to afford extra information on points elucidated by the original series of experiments.

The evidence derived from these additional experiments fully confirms the conclusions drawn from the results of the original series, but from the point of view of the present paper, the greatest interest centres in the latter, owing to the lengthened period covered by them, and also by reason of their more general character.

Description of the Location of the Plots.

The following description of the plots is condensed from the Reports on the Botanic and Experiment Stations :—

ORIGINAL SERIES OF EXPERIMENTS.

Number.	Letter on station plan.	Number of bearing trees per plot.	Area of plot in acres.	Manurial treatment.
1	C	51	0·28	No manure.
2	A	64	0·29	Basic phosphate, 4 cwt. per acre. Sulphate of potash, 1½ cwt. per acre.
3	B	59	0·36	Dried blood, 4 cwt. per acre.
4	E	44	0·29	Basic phosphate, 4 cwt. per acre. Sulphate of potash, 1½ cwt. per acre. Dried blood, 4 cwt. per acre.
5	D	49	0·37	Mulched with grass and leaves.

ADDITIONAL SERIES OF EXPERIMENTS.

Number.	Letter on station plan.	Number of bearing trees per plot.	Area of plot in acres.	Manurial treatment.
6	F	46	·25	Mulched with grass and leaves.
7	G	51	·25	Manured with cotton seed meal.
8	H	82*	·414	No manure.
9	I	84**	·373	Mulched with grass and leaves.

* 8 not bearing; ** 6 not bearing.

Plots A, B, C, D, and E of the original series, and plots F and G of the additional series are situated directly to the east of the office buildings, at the foot of the slopes of Morne Bruce, on land very gently sloping in a south-westerly direction.

Plots H and I are situated on a slope on the sides of Morne Bruce, a short distance eastward of plots F and G; they thus possess a westerly aspect. They were laid out to test the value of the mulching method when applied to cacao grown on the steep slopes characteristic of much of the cultivation in Dominica. The area of these plots is calculated on the basis of the horizontal projection, since it has been found that the returns per acre calculated in this way are more comparable with the results obtained on level land than when they are based on the total surface area, and the adoption of this practice seems desirable wherever it may be necessary to conduct agricultural experiments on steep slopes.

PHYSICAL CHARACTERISTICS OF THE SOILS OF THE PLOTS.

The soils of the plots are of a distinctly light and sandy type; the physical composition of the soils of the plots A to E have been determined by analysis in the Government Laboratory for the Leeward Islands, and the results are given in tabular form below. The analyses represent the average of a number of samples taken to a depth of 1 foot at equal distances throughout each plot.

The method followed in making the physical analyses is the sieve and beaker method of Osborne.

The separated grades are classed as follows, according to the size of the particles:—

	Millimetres.		Inches.	
Stones	above 5		above 0·2	
Coarse gravel ...	5	to 2	0·2	to 0·08
Gravel	2	,, 1	0·08	,, 0·04
Coarse sand ...	1	,, 0·5	0·04	,, 0·02
Medium sand ...	0·5	,, 0·25	0·02	,, 0·01
Fine sand	0·25	,, 0·1	0·01	,, 0·004
Very fine sand ...	0·1	,, 0·05	0·004	,, 0·002
Silt	0·05	,, 0·01	0·002	,, 0·0004
Fine silt	0·01	,, 0·005	0·0004	,, 0·0002
Clay	less than 0·005		less than 0·0002	

In the process of determination, the first four grades are separated by mean of sieves, the remainder by eleutriation and sedimentaion.

Dominica Cacao Manurial Plots.

PHYSICAL ANALYSES.

	Plot A.	Plot B.	Plot C.	Plot D.	Plot E.
Stones	1·0	Nil	2·0	Nil	1·0
Coarse gravel ..	16·6	16·2	14·0	13·1	9·9
Gravel	11·7	11·1	6·8	8·8	5·5
Coarse sand ...	7·6	10·4	8·0	9·8	4·5
Medium sand ...	31·6	31·1	30·4	28·3	21·3
Fine sand	·8	1·1	1·0	1·7	1·2
Very fine sand ...	5·2	4·9	6·4	4·9	5·7
Silt	4·3	6·3	4·3	5·9	5·9
Fine silt	16·4	17·0	21·5	21·2	37·0
Clay	·7	·9	·6	·9	1·7
Organic matter and combined water ..	3·3	3·6	·44	5·2	5·3
Total	99·2	99·9	99·4	99·8	99·0

It will be seen that, on the whole, the soils approximate to a type in which the sandy constituents predominate, but that they evince a tendency to become less sandy as one proceeds westward—a result due to the slight downward slope in this direction. Plot E is the lowest lying of all the plots, and on this account the soil shows a distinctly larger proportion of silt constituents than is the case with the other members of the series, although not to such a large extent as to constitute a marked divergence from the general soil type.

The underlying subsoil forms a continuation of the top soils, and presents a considerable thickness of coarse sands and gravel, through which water percolates freely. During the rainy season the permanent water table usually stands about 8 feet below the surface of the ground, while it sinks to a greater depth during dry weather. The subsoil water-supply is augmented by drainage from the slopes of Morne Bruce.

In order to obtain an exact idea of the manner in which the physical character of the soil varies from point to point in each of the plots, determinations were made of the percentage of shrinkage at equidistant points throughout, samples being taken for the purpose to a depth of 12 inches every 24 feet,

The method of shrinkage has been described in the *West Indian Bulletin*, Vol. XII, pp. 50 to 68. It forms a means of estimating approximately the amount of agricultural clay present in a sample of soil, the percentage of shrinkage observed being an approximately linear function of the content of agricultural clay, i.e. varies directly with it.

The mean results of the shrinkage determinations on each plot are given below in tabular form.

Description of plots.	Number of determinations made.	Mean value of shrinkage, per cent.
Plot A. Phosphate and potash ..	16	2·0
Plot B. Dried blood	21	2·7
Plot C. No manure	21	3·1
Plot D. Mulch	24	4·5
Plot E. Complete manure	24	4·7

It will be seen that, on the whole, the texture of soil varies only slightly throughout the plots, except in the case of plot E, which shows considerably greater local variations, becoming quite heavy at a point near the south-western extremity, while there is a small very light patch in the north-east corner.*

It may be added that the results constitute an example, on a small scale, of the manner in which a series of soil shrinkage determinations may be used to exemplify and to extend the results of a series of physical analyses of soils covering the average of an extended area.

It has already been pointed out that owing to the lengthened period during which the experiments thereon have been in progress, the chief interest from the point of view of these investigations centres in plots A to E; the contributory additional evidence afforded by plots F, G, H and I is, however, considerable, and in order to obtain information as to the physical characters of the soils of these plots, shrinkage determinations have been conducted upon average samples from each, the results of which are given below.

Name of plot.	Shrinkage, per cent.
F. Cotton seed meal	4·7
G. Mulch	4·0
H. No manure	4·0
I. Mulch	4·0

It appears from the foregoing results that the soils of these plots are somewhat heavier than those of plots A, B and C, and approximate fairly closely in texture to those of plots D and E.

* For these determinations Mr. G. A. Jones, Assistant Curator of the Botanic Station, Dominica, is responsible.

This is in all probability due to the contour of the high land of Morne Bruce behind the plot, which causes a larger proportion of the drainage to be directed on to them than is the case with A, B, and C.

SUMMARY OF THE TREATMENT RECEIVED BY THE PLOTS.

The variety of cacao cultivated on plots A to G is, on the whole, of the Forastero type, with a tendency towards the Calabacillo. Plots H and I, on the other hand, are planted with trees of the Amilonado type.

Lengthened experience has demonstrated that the more delicate and finer varieties of the Criollo discription are unsuited to Dominica conditions, and sooner or later tend to succumb to disease—canker (*Phytophthora faberi*). At the inception of the experiments all the plots with the exception of plots H and I contained a number of trees of the Criollo type ; these have periodically died out and been replaced by a more hardy resistant variety.

The plan has been adopted of planting on each plot a sufficient number of trees to cover the ground. The number of trees per acre thus affords an indication of the relative vigour of the cacao ; the greater the number of trees the less vigorous being the growth.

Since the inception of the experiments, the soil of the plots has not received any cultural treatment beyond the application of the manures, save that when necessary, the growth of weeds between the trees have been cutlassed back periodically. When the plots are fully shaded the growth which occurs is practically negligible.

It may be added that the practice of planting shade trees for fully matured cacao is not found to be necessary in Dominica. In addition, the plots have all received the systematic attention in regard to pruning and general sanitation usually considered necessary in a cacao orchard.

The manures and the mulch are applied once a year, usually during the months of May and June.*

In applying the manures the material is spread uniformly over the surface of the ground and then lightly raked under. The mulch is composed largely of grass from the lawns mixed with leaves and pods of the Saman trees (*Pithecolobium Saman*), which surround and shade the lawns. The mulching material is given at the rate of 5 baskets each containing 20 lb. to every tree. In view of the importance of the mulching method as demonstrated by these experiments, the question of the manurial value of various descriptions of mulches is considered in a later section of this paper. The practice adopted in the reports on these experiments has been to record the yields for periods of twelve months terminating on June 30, this date being chosen as least likely to disturb the records as a result of fluctuations of yield due to variations of seasons.

*In practice, the method pursued is to rake away the leafage in a circle round each tree, to apply the manure in the space thus uncovered, and then to rake the leaves back over the manure.

Meteorological Conditions.

The annual rainfall on the plots for each year during which the experiments have been in progress is recorded below.

Period.	Year.	Inches.
Twelve months ending June 30,	1903	72·46
" " " " "	1904	93·68
" " " " "	1905	70·13
" " " " "	1906	74·60
" " " " "	1907	68·02
" " " " "	1908	67·08
" " " " "	1909	69·47
" " " " "	1910	94·90
" " " " "	1911	89·71
" " " " "	1912	80·54
" " " " "	1913	64·76

The question of the relation existing between the rainfall and the yield of cacao is discussed in a subsequent section of this paper.

It is to be regretted that no record of meteorological conditions other than rainfall has been kept, since it is highly probable that the atmospheric temperature, relative humidity, and wind pressure exert an appreciable influence in determining the annual yield.

Description of the Appearance of the Cacao Growing in Each of the Plots.

In August 1913, a careful inspection was made of the plots with respect to the condition of the trees growing thereon. At the initiation of the various series of trials, the condition of the trees was practically uniform throughout so, that the present state of affairs is almost entirely the outcome of the various forms of manurial treatment received.

ORIGINAL SERIES.

No. 1, Plot C (no manure).

Trees decidedly lacking in vigour. Much dead tip; leafage scanty and leaves, on the average, small and off in colour. Ground by no means fully shaded. A considerable number of the original trees have died out and been replaced from time to time. A considerable amount of disease—canker (*Phytophthora faberi*).

No. 2, Plot A (phosphate and potash).

Trees lacking in vigour. Leafage scanty; leaves, on the average, small and off in colour. Plot by no means fully shaded. A considerable amount of epiphytic growth on many of the trunks; large amount of disease (canker). Very little flowering.

No. 3, Plot B (dried blood).

Trees, on the whole, vigorous. Some dead tip. Leafage ample; leaves large and of a good healthy green tint. Plot fully shaded. Some canker. Flowering not very profuse.

No. 4, Plot E (complete manure).

Trees moderately vigorous. Some dead tip. Leafage fairly good, leaves fairly large and of a fairly good colour. Plot on the whole, fairly well shaded, but at one point thin, owing probably to unfavourable soil conditions. Some disease present. Profuse flowering.

No. 5, Plot D (mulched).

Trees very vigorous and well grown. A little dead tip. Leafage abundant and leaves large and of excellent colour. Ground very thickly shaded, no open spaces. A little disease present. Satisfactory flowering.

ADDITIONAL SERIES.

Plot F (cotton seed meal).

Trees vigorous and well grown. Leafage ample, leaves large and of good colour. Plot well shaded. Some disease. Flowering fair and a fair number of pods.

Plot G (mulched with grass and leaves and pods of the Saman tree). General appearance almost identical with plot D.

Plot H (no manure). Situated on hillside.

Trees stunted and lacking in vigor. Leafage scanty, leaves small and off in colour. Ground not fully shaded. Much epiphytic growth. Little or no actual disease, cacao being of the resistant Amelonado type. No great amount of flowering.

Plot I (mulched with grass and leaves). Situated on hillside.

Trees healthy, well grown and vigorous. Leafage abundant. Leaves large and of a good colour. Plot fully shaded, no epiphytic growth. Satisfactory flowering. Little or no disease as in the case of plot H, the variety being of the hardy resistant Calabacillo type.

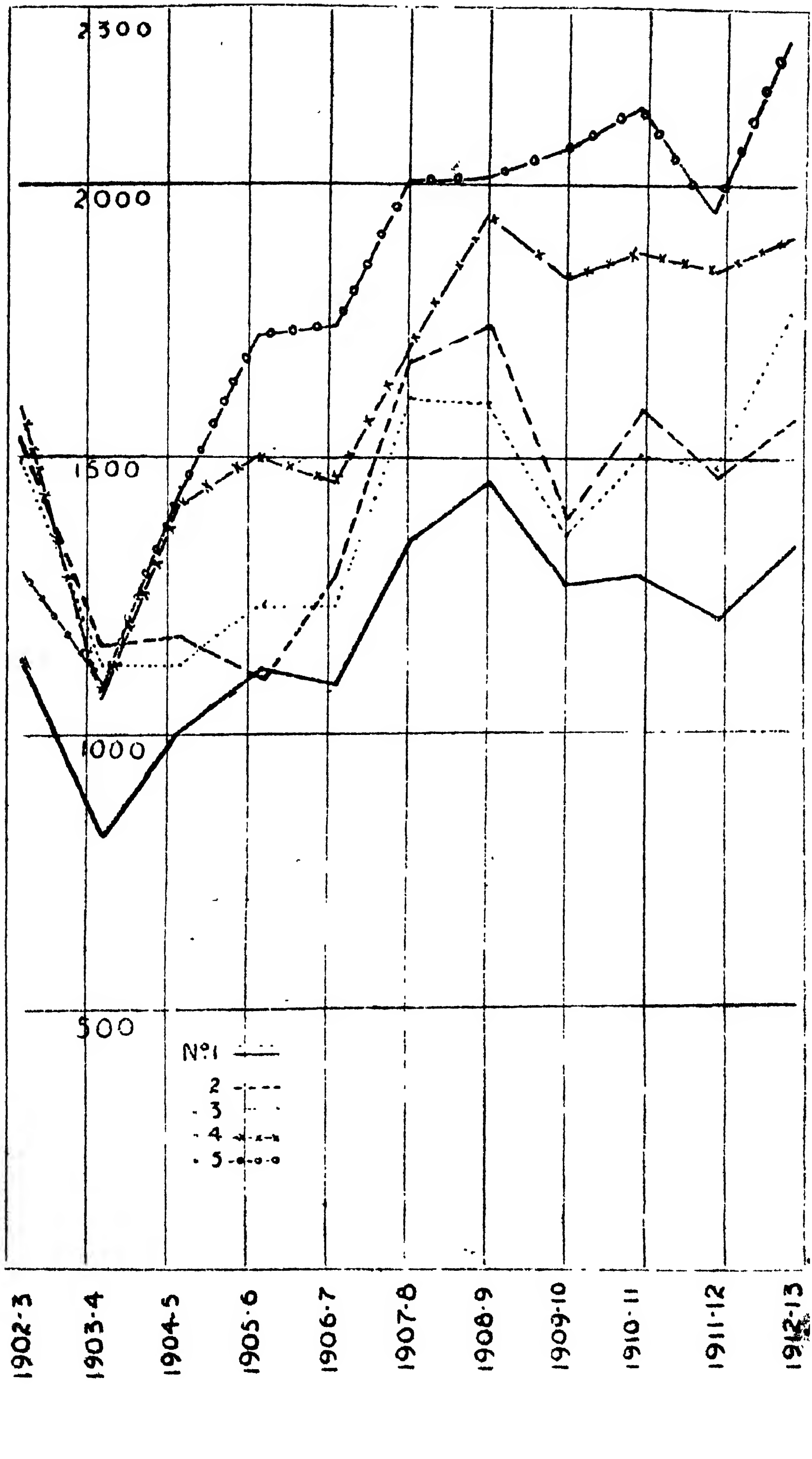
THE YIELDS RECORDED FROM THE PLOTS.

The following table gives in condensed form the returns from each of the plots during the period covered by the experiments; the yields have been calculated in terms of cured cacao, ℔. per acre.

The mean results show clearly the effect of the various forms of manurial treatment applied to the plots; the best result has been given by plot D, which was mulched with grass and leaves, while plot E, which received the complete manure, follows with the next highest yield.*

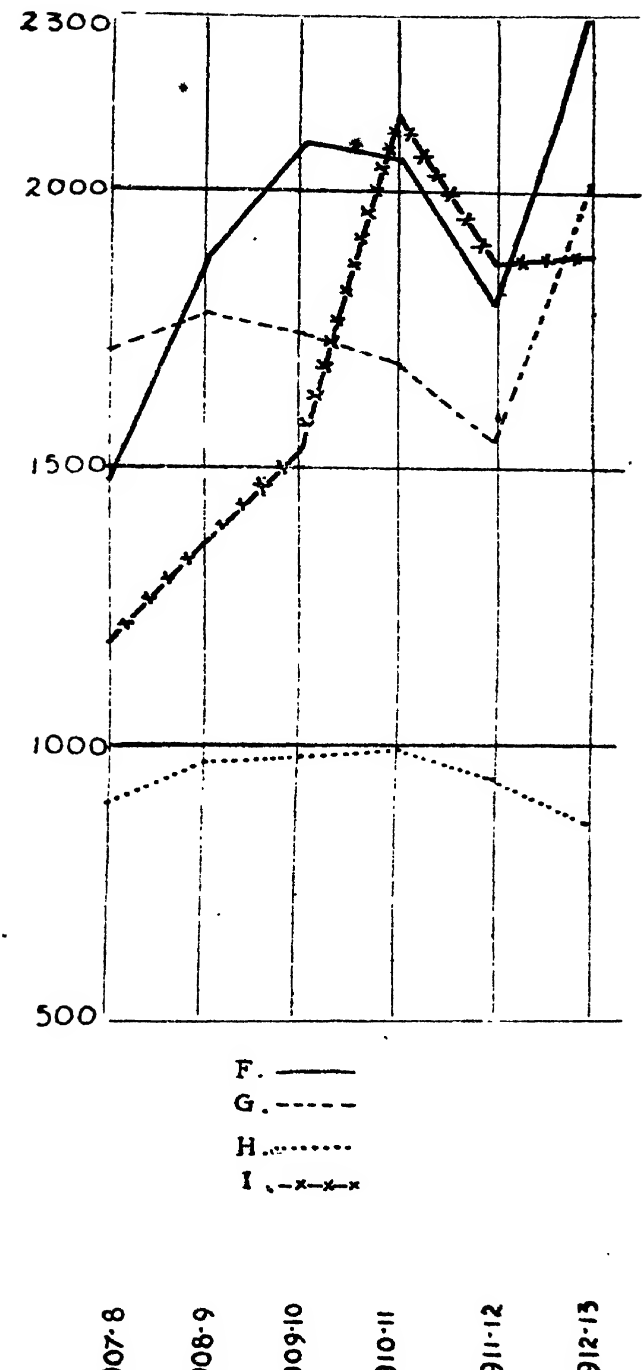
* The very marked drop in the yields from all the plots in the year 1913-14 is due to the trees having suffered somewhat severe damage from winds experienced during the gale in August 1913.

PLATE I.



2300
2000
1500
1000
500
Nº1
2
3
4
5
1902-3
1903-4
1904-5
1905-6
1906-7
1907-8
1908-9
1909-10
1910-11
1911-12
1912-13

PLATE II.



2300
2000
1500
1000
500
F.
G.
H.
I.
1907-8
1908-9
1909-10
1910-11
1911-12
1912-13

YIELDS IN TONS OF CURED CACAO, POUNDS PER ACRE.

Year.	No. 1 Plot A. No manure.	No. 2 Plot A. Phosphate and potash.	No. 3 Plot B. Dried blood.	No. 4 Plot E. Dried blood, phosphate and potash.	No 5 Plot D. Mulched.	No. 6 Plot F. Mulched.	No. 7 Plot G. Cotton seed meal.	No. 8 Plot H. No manure.	No. 9 Plot I. Mulched.
1902-3	1,138	1,540	1,494	1,599	1,300	...	...	...	...
1903-4	822	1,170	1,131	1,069	1,092	...	...	...	...
1904-5	1,009	1,179	1,131	1,418	1,150	...	...	...	...
1905-6	1,122	1,105	1,232	1,506	1,724	...	..	...	..
1906-7	1,095	1,285	1,134	1,461	1,713	...	...	...	...
1907-8	1,354	1,680	1,611	1,709	2,012	1,480	1,712	895	1,186
1908-9	1,167	1,715	1,607	1,946	2,017	1,880	1,781	971	1,367
1909-10	1,272	1,395	1,361	1,835	2,068	2,087	1,746	979	1,528
1910-11	1,288	1,589	1,504	1,879	2,145	2,058	1,690	991	2,136
1911-12	1,206	1,466	1,484	1,812	1,953	1,798	1,519	937	1,870
1912-13	1,338	1,576	1,761	1,903	2,271	2,313	2,028	857	1,885
Mean ...	1,190	1,130	1,405	1,653	1,798	1,931	1,751	937	1,662

The results, as a whole, are of considerable interest; their relative values and fluctuations are most effectively displayed in graphic form, and in Plates I and II, curves are given showing the annual fluctuations in the yields from the several experiments.

In Plate I the returns from the original series of experiments are displayed, while Plate II gives those obtained in the two additional series.

Inspection of these two curves shows that while in the case of the No Manure plots, C and H, the returns fluctuate closely around a mean value, those for the plots which received manure show, on the whole, a distinct upward tendency in the earlier years of the experiments, and subsequently settle down to fluctuations around a mean value higher than that of the No Manure plots.

Moreover, when this value has been attained, the annual fluctuations in yields are less marked in the cases where the plots have received a dressing supplying all the various manurial constituents, than when the dressing is incomplete in character.

The important corollary follows, that in applying manures to orchard cultivation under conditions such as those governing these experiments, a period of from three to five years will usually be required to elapse before the trees settle to the standard of fertility conditioned by the treatment applied.

During the period covering these experiments none of the plots has evinced any marked decreases of yield as a result of witholding any one manurial constituent. Even in the case of the No Manure plots, no decided falling off has as yet become evident, and the effect is chiefly shown by the relatively low average level of the returns, and the condition of the trees themselves.

It remains to be seen how far the effect of the continuous witholding of manure will result in decreased yields in subsequent years, but the existence of numerous areas of cacao in Dominica which for long periods have received no manurial treatment, and which continue to produce small yields of cacao, appears to give ground for the belief that, under these conditions, a low productivity may be maintained, if not indefinitely, at any rate for protracted periods of uncertain length (a result analogous to those obtained in the Rothamsted experiments on annual crops in a temperate climate).

The Probable Error Involved in the Results.

Of recent years considerable interest has attached to the calculation of the mean probable error involved in the performance of agricultural experiments. In making such calculations two factors require to be taken into consideration in the case of these plots, viz :—

(a) Variations in yield due to variations in season.

(b) The cumulative effect of the manurial application felt over a term of years, the existence of which has been demonstrated, and which in the early years of the application entails in general a steady rise in the returns from the plots. Nevertheless the fact that these experiments have been extended to include in each year a series of three trials of the mulching method and also two no manure plots, enables certain calculations to be made in this way. In making these calculations the values given by plots F and I in the years 1906-7 and 1907-8 have not been taken into account, since during that period the productivity of these plots was increasing owing to the accumulative effect of the manurial applications. The following data give the mean probable error for the mean of the three mulched plots for each of the years 1909-10 to 1912-13, in terms of cured cacao, lb. per acre. Below is given the mean probable error attached to the mean of the three plots for the four years, together with the mean probable error for one experiment.

The calculations have been made by Peters'* approximation formula.

Year.	Plots E, F, and I. probable error of mean result, lb. of cured cacao per acre.	Mean probable error, per cent.
1909-10	±138	±7·1
1910-11	±22	±1·0
1911-12	±32	±1·7
1912-13	±63·5	±3·2

Mean of these plots for four years

Mean probable error of one experiment ±132 lb. or 6·7 per cent.

" " " " ±38·5 " 1·9 " "

the latter calculated value includes variations in yield due to variations of seasons on addition to errors due to other causes. In addition to the above, the mean probable error of the two series of no manure plots has been calculated for the entire series of years during which they have been in progress.

	Plot C.	Plot H.
Mean probable error of one result,	120 lb. or 10 per cent.	39·1 lb. or 4·2 per cent.
Mean probable error of mean	36 lb. or 3 per cent.	15·9 lb. or 1·7 per cent.

While below are given the probable errors for each of the other plots A to E after the initial period has elapsed during which they have been settling down to the conditions incident on the system of manuring applied.

* If r is the probable error of the results of a single plot and R that of the arithmetical mean of the results from all the plots, S (+v) is the sum of the deviations of every result from the arithmetical mean of all the results, and n the number of plots employed, the formulae are :—

$$r = \pm 0{\cdot}8153 \frac{S(+v)}{\sqrt{n(n-1)}}$$

$$R = \pm 0{\cdot}8453 \frac{S(+v)}{n\sqrt{n-1}}$$

	Plot A.	Plot B.	Plot D.	Plot E.
Mean probable error of one result.	90·2 lb or 5·7 per cent.	98·5 lb. or 10 per cent.	81·5 lb. or 3·9 per cent.	53·4 lb. or 2·9 per cent.
Probable error of mean.	36·4 lb. or 2·5 per cent.	39·9 lb. or 2·6 per cent.	33·0 lb. or 1·6 per cent.	21·8 lb. or 1·2 per cent.

It has already been pointed out that calculations of the above type, which include the results of a series of experiments carried out over a number of seasons, and which do not include a factor for variation due to seasonal conditions, are liable to give values for the probable error that are too high on that account.

In the case of these experiments, the conditions under which they are carried out are, on the whole, equable, so that the fluctuations on this account are small.

In any case the calculations substantiate the reliance placed on the results of the trial, since in practically all cases the increases resulting from the applications of manure considerably exceed the probable error, while the concordant character of the results and the condition of the trees lend additional weight to this conclusion.

Chemical Characteristics of the Soils of the Plots.*

In order to obtain information as to the effect of the various manurial applications on the soils of the plots, a chemical examination was made of the soils of each during the year 1912-13.

In the case of plots A to E, the samples were taken in May 1912 prior to the annual application of the manures; while in the case of plots F, G, H, and I the samples were taken in August 1913 after the application of the manures. In every case the samples were taken to a depth of 1 foot throughout the plots, and each sample analysed represented the average of a number of samples taken at equidistant points.

On the soils of plots A to E were determined the nitrogen content by Kjeldahl's method, the total organic carbon and the carbonates by the methods given in the Report on the Soils of Dominica (Imperial Department of Agriculture, 1902), the available phosphoric acid and potash by Dyer's citric acid method, and the chlorine by extraction with distilled water.

On the soils of plots F, G, H, and I the nitrogen and organic carbon were alone determined.

From the content of organic carbon as determined, the humus content has been calculated by multiplying the result by

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* It may be stated that for many years past it has been recognized in the Government Laboratory for the Leeward Islands, that the so-called humus content of soils consists in reality of a highly complex mixture of organic compounds formed by the degradation of plant and animal remains; in consequence, the estimation of the humus content as such presents considerable difficulties, and the results when obtained are of doubtful significance, especially when considered in relation to soils of different type. Consequently the plan has been followed of estimating the total content of organic carbon present in soils by oxidation with chromic acid after the method of Cross and Bevan, and calculating therefrom an empirical value for the humus content. Such a method, while affording no information as to the specific character of the various compounds of which the humus complex is made up, forms a simple and accurate basis for the comparison of the total content of organic matter. It is true that certain arid and sandy soils may contain considerable amounts of vegetable organic matter in a practically unaltered condition, but in cases when this occurs, the fact can always be noted and allowance made for it when interpreting the results. It may be added that the hot moist conditions occurring on the Dominica cacao plots effectively inhibit such an occurrence in the present case.

the factor 1·724, while from the contents of carbon dioxide and chlorine the equivalent calcium carbonate has also been calculated. The accompanying table shows the results obtained in the various determinations.

Dominica Cacao Manurial Plots.

CHEMICAL ANALYSES.

	Plot A.	Plot B.	Plot C.	Plot D.	Plot E.
P_2O_5 sol. in 1 per cent. citric acid	·0195	·0206	·0158	·022	·0285
K_2O sol. in 1 per cent. citric acid	·0477	·0313	·01735	—	·0554
Carbon dioxide	·055	·046	·044	·049	·046
= calcium carbonate ..	·124	·104	·100	·112	·104
Nitrogen	·088	·118	·098	·193	·130*
Organic carbon	1·087	1·479	1·094	1·756	1·481
= humus	1·794	2,550	1·885	3·027	2·553
Chlorine	·065	·072	·066	·100	·097
= sodium chloride ..	·107	·119	·109	·165	·160

CHEMICAL ANALYSES.—(*Contd.*)

	Plot F.	Plot G.	Plot H.	Plot I.
Nitrogen	0·182	0·143	0·101	0·158
Organic carbon	1·630	1·290	0·945	1·555
= humus	2·810	2·224	1·629	2·680

The effects of the various applications are shown in the contents of the different constituents in the soils of the plots. It is a general characteristic throughout, that they are markedly deficient in calcium carbonate. In respect of the nitrogen content, the mulched plot D is by far the highest, while it is followed by

* The nitrogen content of plot E was determined on a fresh sample taken in August 1913, the original determination in 1912 having been lost.

plot E, which received the complete manure. Plot B shows a lower nitrogen content than plot E, though it has received the same manurial treatment; this is probably accounted for by greater leaching losses owing to the more open character of the soil, and the slightly greater elevation of the plot. Plots A and C, of which neither has received nitrogenous manures, show nitrogen contents below those of the other plots, as is to be anticipated.

With regard to the question of available phosphoric acid and potash, plot E here shows decided pre-eminence, and is followed in respect of potash by plot A, the smaller accumulations in the latter case being again accounted for in all probability by greater leaching losses. Inspection of the results also tends to create the impression that on this account the soil of plot B may have received some small accretions of phosphoric acid and potash from plot A.

No means at present exist for measuring the leaching losses taking place from the different plots, but inspection of the above results combined with a knowledge of the physical characteristics of the soils and contour of the land points undoubtedly to their being greatest at the upper end of the plots and diminishing gradually to plot E.

The results in relation to the content of organic carbon, on the whole, follow those found in the case of nitrogen, being highest in the case of plot D, and lowest in plots A and C. The question of the relationships of the plots in this respect is considered further at a later stage of this paper.

With regard to plots F, G, H, and I, the fact that they have been in existence for a shorter period than the original series has caused the effect of the manurial applications to be less marked. Nevertheless, so far as the nitrogen contents of the plots are concerned, the results are substantially in accord with those obtained from plots A to E. Both of the mulched plots F and I show considerable accumulations of nitrogen, though this is less in the case of the hillside plot. I. than in that of plot F. Probably the lower nitrogen content of plot I is accounted for, at any rate in part, by the considerable incline on which the plot is situated, and which would tend towards greater leaching losses. The condition of plot F at the present time approximates closely to that of plot G.

The Manurial Gains and Losses which Have Accrued to the Plots.

It now becomes of interest to investigate the various gains and losses of manurial material which have taken place on the plots during the progress of the experiments.

The quality of the manures applied to the plots has from time to time been controlled by analyses, and the contents of plant constituents may, on the average, be taken as follows:—

Basic slag	phosphoric acid	16	per cent.
Sulphate of potash	potash	50	„ „
Dried blood	nitrogen	12	„ „

With regard to the mulching material, the following analysis was performed in the Government Laboratory for the Leeward Islands some years ago; it has appeared on several occasions in annual reports on these experiments but is reproduced below for convenience of ref erence: —

Nitrogen	2·116 per cent.	on air-dry material.
Phosphoric acid	0·156 per cent.	
Potash	0·644 per cent.	

The presence of the Saman pods and leaves has resulted in the application of a mulch which is decidedly rich in nitrogen.* At the end of this paper a number of other analyses of mulching material are collected which serve to illustrate the manner in which the composition of this class of substance varies with its origin.

It should be stated that the amount of mulching material containing considerable quantities of Saman leaves and pods, which was applied to plots F and G, was insufficient to supply a complete dressing to plot I, and it has been customary to bring the amount of material supplied to this plot up to the full quantity with leaves and grass cut from the slopes of Morne Bruce. It is estimated that the Saman—containing material constituted about one-fourth of the total amount supplied; in consequence, the dressing applied to this plot is less rich in nitrogen than those given to plots D and F.

As the result of a number of analyses at different times, it is assumed that manurial constituents are contained in cotton seed meal in the following proportions: —

Nitrogen	4·5 per cent.
Phosphoric acid	1·2 ,, ,,
Potash	1·2 ,, ,,

From these data the amounts of manurial material conveyed to A to G plots, in lb. per acre, annually, is summarized below.

	A.	B.	C.	D.	E.	F.	G.
Nitrogen ...	nil	54	nil	223	54	223	27
Phosphoric acid	72	nil	nil	17	72	17	7·2
Potash	84	nil	nil	71	84	71	7·2

* The physical composition of the sample in question was as follows: —

Saman pods and twigs	70·18 per cent.
Leaves and grass...	28·2 ,, ,,

It has been suggested that the above analysis of a single sample may not fully represent the character and the mulching material on all occasions, While this may be the case to some extent, there is no doubt that the presence of Saman pods tends to raise the nitrogen content considerably, and on all occasions these constituted a predominating proportion of the mulching material applied to plots A to E.

The subject of the composition of mulching material is further dealt with in the appendix of this paper.

It will be seen that the application of the mulch has resulted in giving a very heavy dressing of nitrogen to plots D and F, and no doubt some part of the beneficial effect observed must be attributed to this cause.

The next point calling for consideration is the amounts of manurial material removed from the plots in the crop in each year. It may here be stated that throughout the course of these experiments, the practice has been to remove the entire produce from the plots, the husks and pulp not being returned subsequently.

The following data, determined by Mr. G. A. Jones on pods of the Forastero-calabacillo type of cacao, which constitutes the main type grown on plots A to G, afford information as to the proportion borne by the weight of the whole fruit to the yield of cured cacao.

Two determinations were made, and as a result it was found as follows :—

A. 100 lb. pods gave 8·62 lb. cured cacao
B. 100 lb. " " 7·55 " " "

A third determination conducted in the Government Laboratory for the Leeward Islands showed that 100 lb. pods gave 8·75 lb. sun-dried cacao and pulp.

Taking the mean of the first two determinations (the third being excluded on account of the uncertain weight of the pulp and also the method of curing), we find as a mean value, that 100 lb. of fruit of this type gave 8·08 lb. of cured cacao.

For the purpose of this investigation, determinations were further made in the Government Laboratory for the Leeward Islands of the contents of nitrogen, phosphate and potash, of the husks and the beans and pulp of cacao of this type. The results are as follows :—

	A. Fresh husks. per cent.	B. Fresh beans and pulp, per cent.
Nitrogen ..	0·182	0·721
Phosphoric acid	0·049	0·727
Potash	0·297	0·453

From the above data the contents of manurial constituents ·› the whole fruit have been calculated and are given below* :—

	Fresh pods, per cent.
Nitrogen ..	0·312
Phosphoric acid	0·213
Potash	0·335

*For comparison, Professor Harrison's values for Forastero and Calabacillo cacao are quoted below.

Forastero. 100 lb. fruit gave 3·6 lb. of cured cacao.
Calabacillo. 100 lb. ,, ,, 7·25 ,, ,, ,, ,,

The contents of manurial constituents condensed from Professor Harrison's detailed figures were found to be as follows :—

	Forastero, per cent.	Calabacillo. per cent.
Nitrogen	0·278	0·325
Phosphoric acid ..	0·147	0·152
Potash	0·368	0·468

It will be seen from the above that the nitrogen contents found for the Dominica Forastero-calabacillo lies midway between Harrison's values for the two varieties, while the phosphoric acid is decidedly higher and the potash lower than the values found by him in either case.

From the above data it is possible to calculate the approximate amounts of manurial material removed in the crops from plots A to G in lb. per acre, and the results of this calculation are given below. The returns from plots H and I are not included therein, since, as previously stated, the variety of cacao cultivated thereon is of the Amelonado type and may in consequence be expected to differ in its content of manurial constituents from the Forastero—calabacillo cacao.*

Average amount of manurial constituents removed per acre per annum in crop in lb.

	A.	B.	C.	D.	E.	F.	G.
Nitrogen ...	55·0	54·0	45·8	74·2	68·5	74·5	67·5
Phosphoric acid	36·7	36·1	30·6	69·0	63·7	49·7	45·1
Potash	59·2	58·2	49·2	46·1	42·6	79·9	73·6

* Some considerations in this connexion in respect of plots H and I are included at a later stage.

It is thus possible approximately to ascertain by comparison how far the amounts of manurial material added to the different plots counterbalance the amount removed in the crop.*

In respect of nitrogen, the dressings of dried blood given to plots B and D very approximately equalize the amount annually removed in the crop. In regard to plots D and F, the annual application of nitrogen far exceeds the amount removed in the crop, while in the case of plot G, the amount of nitrogen removed is considerably in excess of the amount added. Plots A and C, on the other hand, have annually been suffering considerable losses which are not replaced by corresponding dressings of manure.

With regard to phosphoric acid, the amounts of the constituent removed in the crops are decidedly less than the amounts added in manure applied to plots A and E, but considerably exceed the quantities received by plots D, F, and G. In relation to potash, the amounts received by plots A and E exceed the quantity removed; on plots D and F the amount removed is approximately equal to that added, while in plot G the amount removed largely exceeds the amount added.

As a corollary to the above, the following data give the approximate total amounts of plant food removed in the crops from the plots during the entire course of the experiments:—

	Eleven years.					Six years.	
	A.	B.	C.	D.	E.	F.	G.
Nitrogen .	615·0	594 0	503·8	759·0	657 8	447·0	405·0
Phosphoric acid	403·7	397·1	336·6	507 1	468·6	298·2	270·6
Potash ...	651·2	640·2	511·2	876·2	753·5	179·1	111·6

On the whole, the results cause one to incline to the view that when adequate dressings of nitrogen are applied combined with considerable amounts of organic matter, the natural reserves of potash and phosphate present in the soil are for the present sufficient in quantity, and are liberated with sufficient rapidity to meet the demands of the crop in these respects.

Moreover, applications of organic matter tend to stimulate bacterial activity, and the decomposition of humus thus promotes a more rapid rate of availability for the reserves of potash and phosphoric acid in the soil, owing to the more abundant evolution of carbon dioxide thereby engendered.

The case of plots G and B, which received cotton seed meal and dried blood, respectively, especially seem to strengthen this view by reason of the relatively high content of organic matter contained by the manure, which on this account would promote liberation of potash and phosphate and thus account for the steadily satisfactory yields experienced, in spite of the fact that the additions of phosphoric acid and potash may have been very small.

* No allowance is made for the quantities of manurial material removed in the operations of cutting out dead wood, pruning or suckering: on this account the actual amounts of material removed must in the case of any plot be supplemented by an approximately constant unknown quantity of manurial material.

It may be added that the question of bacterial relations is further discussed in certain aspects at a later point.

Especial interest centres in the question of the supply of nitrogen, and we may now proceed a step further and endeavour to consider the position of the five plots of the original series of experiments in relation to the total nitrogen contents of the soils of the plots, and the losses and gains which have accrued to them during the period of the experiments.

To this end, the nitrogen contents of the plots have been calculated per foot-acre from the analytical data already given. For the purposes of the calculation the weight of a foot-acre of soil of this type has been assumed to be 3,300,000 lb.—a figure based on the value given by A. D. Hall for a sandy loam, to which type the soils of the plots approximate throughout. The slight departure from the type shown by plot E is insufficient to affect the figure very materially. The figures in any case are only approximations, but serve to indicate the relative magnitude of the nitrogen* contents of the soil.

Nitrogen contents of plots A to E in lb. per foot-acre.

	A.	B.	C.	D.	E.	F.	G.
Nitrogen in lb. per foot-acre ...	2,910	3,900	3,240	6,380	1,330	6,020	4,720
Date of determination ...	May 1912	May 1912	May 1912	May 1912	Aug. 1913	Aug. 1913	Aug. 1913

The losses and gains of nitrogen which have accrued to the plots may be divided into two groups: (a) those known with approximate accuracy, (b) those which are unknown. The first group include the material added in the manurial application and that removed in the crop. The second group comprise the nitrogen added in the rainfall, that removed in the operations of pruning and sanitation, and that lost by leaching and through the operation of denitrifying organisms. In regard to the latter group, an approximate estimate may be formed from data supplied by observers elsewhere of the quantities of nitrogen furnished annually in the rainfall.

With reference to the nitrogen losses sustained by the plots by the removal of pruned out material, and by leaching and denitrification, no data are available to enable the amount of these losses to be calculated; but it is reasonable to suppose that they are approximately constant throughout the plots, although there may be some small tendency for the leaching losses to be heavier on plots A, B and C than on plots D and E, while the amount of pruning will probably be greatest on those plots which

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* It must be remembered that this value is exclusive of the content of nitric nitrogen; but as is shown later, this is very small, at any one time.

have made the most growth, namely D and E.* In the statement given below, the known losses and gains of nitrogen [to the various plots are summarized, and to this is added a figure for the theoretical nitrogen content of each of the plots based on the amount contained in the No Manure plot, on the assumption that the nitrogen contents of the other plots will differ from that of the No Manure plot by an amount dependent on the algebraic sum of the independently variable gains and losses to the plots resulting from the application of the manures and the reaping of the crops.

It may be added that in the case of plots A, B, C, and D, the calculations have been made to apply up to May 1912 and before the applications of manure in that year, since it was at that time the samples for analyses were taken. In respect of plots E, F and G, on the other hand, the calculation applies up to August 1913.

	A.	B.	C.	D.	E.	F.	G.
Nitrogen removed in crop ...	546	530	451	686	701	447	405
Nitrogen added in manure ..	nil	486	nil	2,007	594	1,338	162
Theoretical nitrogen content of plot in lb. per ft-acre ...	3,148	3,646	3,240	5,015	3,587	—	—
Excess actual nitrogen over calculated in lb. per foot-acre.... ...	− 238	+ 254	—	+ 1,365	+ 693	—	—

The above figures, while they can only be regarded as approximate in value indicate, however, that the balance of losses and gains in the case of the different plots varies very considerably. In the case of plot A, which received no organic manure, the calculated nitrogen content of the plot is distinctly higher than that actually found, but in the case of all the other plots, except of course plot C, the calculated nitrogen content is less than that actually found. As has been pointed out, the losses by leaching are probably less great in the case of plots D and E than with the remaining members of the series (especially in the case of plot E); but while this may perhaps account for the greater excess nitrogen content of plot E as compared with plot B, nevertheless it does not account for the very large excess nitrogen content of plot D. The high nitrogen content of plot D is again reproduced in plot F, but the absence of an exactly parallel

* The gain of Nitrogen from rainfall is also approximately constant throughout.

control plot precludes the making of calculations with regard to the excess nitrogen content of the soils of this plot and also plot G. On this evidence, however, we are apparently faced with the conclusion, that on those plots which have been manured with organic manures, considerable accretions of nitrogen have been taking place independently of the manurial additions which have been made, and that these accretions are of the greatest magnitude in the case of the mulched plots.*

Further corroborative evidence of the correctness of this view is afforded by the hillside plots, H and I. The type of cacao grown thereon differs from those of plots A to G, being of the Amelonado type. In order to enable a similar approximate calculation to be made, determinations were made of the nitrogen content of this type of cacao similar to those already given in relation to the variety grown on plots A to E. The results are as follows :—

	A. Fresh husks.	B. Fresh beans and pulp.
Nitrogen	0·128 per cent.	0·947 per cent.

From the above data the nitrogen content of the whole fruit was calculated and found to be as follows : —

	Fresh pods.
Nitrogen	0·357 per cent.

As already stated, the mulching material utilized on plot I differs somewhat in composition from that used on plots D and F ; no exact analytical data for the nitrogen content of it are available, but it seems not unlikely that it may be somewhat lower than is the case with the material applied in the other two cases. In the following calculation, the gain of nitrogen resulting from the application is however assumed to be the same as on plots D and F, and on this basis we arrive at the results given immediately below.

* It might perhaps be argued that the high value for the nitrogen content of plot D may be the result of greater retentivity imparted to it owing to the increase of the humus content following on the heavy organic manuring. This view is however negatived by the actual moisture determinations of the soils of the plots, which are reported on in a later section of this paper, and which do not show any marked increase in the case of plot D as compared with other members of the series.

	Plot H.	Plot I.
Total nitrogen removed in crop for six years	243lb.	410lb.
Total nitrogen added in manure in six years ...	—	1,338lb.
Nitrogen per foot-acre of soil in plot as determined ...	3,315lb.	5,200lb.
Calculated nitrogen per foot-acre of soil	—	4,486lb.
Excess of actual nitrogen in lb. per foot-acre over calculated value	—	714lb

It may be pointed out, that if the nitrogen content of the manure is lower in this case than the assumed value, the gain of nitrogen represented by the excess of the actual over the calculated content of the soil would be greater than is shown.

The losses incident on leaching may also be expected to be greater in the case of these two plots than with the other members of the series, by reason of the steep slope on which they are situated, and which facilitates drainage; notwithstanding this, however, and also the considerations pointed out in the preceding paragraph, a large excess is seen in the actual over the theoretical nitrogen content of the soil of the plot.

The most reasonable explanation of these accretions of nitrogen appears to lie in the action of nitrogen-fixing organisms of the azotobacter type; the existence of these organisms is now well recognized, and their presence has been demonstrated in various soils from different parts of the Leeward Islands.* The question would therefore appear to be involved in the bacterial relationships of the soils of the plots. This subject is now recognized as being of prime importance in relation to questions of soil fertility, and is intimately bound up with that of the humus supply; consequently it is convenient to deal with the further aspects of the question in relation to the humus contents of the soils of the plots, in which connexion certain other aspects of the bacterial relationships of these soils are also considered.

The Content of Organic Matter of the Plots and Certain Aspects of the Bacterial Relationships of the Soils.

It is now generally admitted that the content of organic matter of a soil is intimately involved in the question of its fertility. Apart from any influence which it may exert in modifying physical characteristics of soils, the supply of organic

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* See Report on Sugar-Cane Experiments in the Leeward Islands for 1909-10. Part II, p. 33.

matter serves as the source from which the energy necessary for the maintenance of a considerable proportion of the bacterial activities of the soil is derived.

In tropical countries, conditions are naturally peculiarly favourable to the maintenance of great bacterial activity of all descriptions, and the processes involving changes of this type will proceed far more rapidly than in temperate climates.

The soils of the plots being, on the whole, light and well drained, are of a type peculiarly favourable to the maintenance of bacterial activity of certain types. In this connexion, those functions which owe their origin to organisms of the putrefactive type and result in the breaking down of organic matter with accompanying liberation of carbon dioxide are of much importance. Intimate relations exist between activities of this description and the liberation of the reserve supplies of potash and phosphoric acid contained in the soil.

With a view to obtaining information in relation to this and other bacterial conditions obtaining in the soils of the plots, the following experiment was performed in the Laboratory. Lots of approximately 1 kilogramme each of theaverage soil samples from plots A to E were put up in glass dishes covered with clock glasses and kept continuously moistened with distilled water for a period of six months. The dishes were kept in the dark, and at the end of the period in question the soils were air-dried, resampled, and the organic carbon content redetermined ; at the same time the nitrogen content of the soils was redetermined by Kjeldahl's method, and also the nitrate content by the Schloesing method.

The results are summarized below :—

	A.	B.	C.	D.	E.
Original content of organic carbon	1·087	1·479	1·094	1·756	1·481
Equivalent humus	1·874	2·550	1·885	3·027	2·553
Original nitrogen content ...	·088	·118	·098	·193	·130
Content of organic carbon at end of experiment	0·800	0·750	0·835	1·255	1·183
Equivalent humus	1·379	1·293	1·440	2·163	2·043
Nitrogen content at end of experiment	·094	·080	·097	·130	·132
Nitrogen content as nitrate at end of experiment ...	·0021	·0016	·0028	·0042	·0012
Percentage loss of humus in six months	26·2	49·1	23·7	28·5	20·3

In respect of the humus content, it will be seen that in every case very marked decreases in the humus contents of each sample have taken place. It is not clear why the loss indicated in the case of soil from plot B should have been so excessive. If this result is excluded, it is seen that the rate of decay of humus has proceeded at a roughly uniform rate in relation to the total initial content of organic matter, the total loss ranging between 20 per cent. and 28 per cent. of the original amount present. It is worthy of note, however, that the highest percentage loss as well as the largest total loss of humus is recorded from plot D.

Figures such as those given above are not, of course, strictly comparable with actual conditions, but it may be observed that the state of affairs obtaining on the cacao plots themselves is not so very dissimilar to that of the experiment in question, at any rate in the case of those plots in which the condition of the cacao trees is satisfactory ; since the heavy shade of the trees and the thick covering of fallen leaves on the ground combine with the usually humid condition to produce a state of affairs approaching to that of the experiment. When the plots are not fully shaded and the soil is in places exposed to the direct rays of the sun, the bacterial activity is no doubt distinctly diminished; but if, as seems reasonable to suppose, the humus losses approximate to those recorded above in the case of the adequately shaded plots, it points in no uncertain way to the necessity for regarding the maintenance of the humus supply as a first essential in systems of tropical agriculture.

In this connexion, it is interesting to turn again for a moment to the analytical results for the determinations of the organic carbon contents of the soils of the plots given in an earlier section of this paper. As is to be expected, this is highest in the case of the mulched plots in every case, and is lowest for those which have received no organic manure, those plots which have been manured with cotton seed meal and dried blood occupying an intermediate position.

On the other hand, the excess of the amounts of organic matter contained in the soils of the mulched plots over the contents of those plots which have been manured in other ways, is not comparable with the differences in the actual amounts of organic matter supplied, and we are therefore forced to conclude that the amount of organic matter which has been broken down by bacterial action on these plots is considerably in excess of the amount which has been removed in this way in the soils of other members of this series—a result which is in general accordance with the indications shown above.

The next point calling for consideration in relation to the above results is the alterations which have taken place in the nitrogen content as the result of the treatment of the soils. The low value for the nitrogen content of plot D after six months must be regarded as abnormal, in the light of the results obtained in the case of the other plots; if we except this result, we see that in the main, but little change has taken place in the nitrogen content of each plot, and in the case of plots A, C and E there is evidence of a slight rise.

The figures in relation to the contents of nitric nitrogen are especially interesting. At the outset, certain of the soils were

examined for the presence of nitrates and only small traces found to be present; the amount of nitrates found at the end of the experiment is therefore presumed to be an approximate index of the total amount of nitrification which has taken place in the interval. In view of the small proportion of lime present in the soils of the plots, the amount of nitrate formed in the course of six months is rather more than expectation would indicate, and if the assumption is again made that the conditions approach to those actually obtaining, the amount of nitrate formed in one year would approximate in most cases to the amount removed in the crops, irrespective of leaching losses. It is interesting to observe that the largest amount of nitrification has taken place in the case of plot D.*

Attention has already been directed to evidence pointing to the existence of large accretions of nitrogen to the soils of the plots apart from additions of this element given in the shape of manure, and the probability that free nitrogen-assimilating organisms may be responsible for the result in question.

To obtain information in relation to this point, a series of experiments was performed in September 1913, in which samples of fresh soil from each of the plots were inoculated into suitable culture media and the amount of nitrogen fixed, determined by analysis.

The culture solution used in these trials was that described by S. F. Ashby (*West Indian Bulletin*, Vol. VIII, p. 94, and *Journal Agricultural Science*, Vol II. p. 35), which has the following composition :—

Mannite	12	grammes
Di-potassium phosphate ...	·2	„
Magnesium sulphate ...	·1	„
Sodium chloride	·1	„
Distilled water	·1	litre

This solution was divided up into lots of 100 c.c., and to each was added 5 grammes of precipitated calcium carbonate; these lots were then intermittently sterilized on successive days and subsequently inoculated with 1 gramme of fresh soil from each of the plots A to E. Each inoculation was performed in duplicate; in addition two uninoculated portions of 100 c.c. each were retained as controls. Typical growths of azotobacter occurred in from two to three days in the case of each of the inoculated lots, while the blanks remained sterile. At the end of a fortnight the nitrogen content of the liquid in each of the flasks was determined by the Kjeldahl process. The various amounts of nitrogen fixed in each case are shown in the following table; the nitrogen originally contained in the soil used for inoculation has been deducted in each case :—

* In this connexion Dr. Watts has suggested to the writer, that under conditions in which the supply of free mineral bases in the soil is deficient, ammonia formed in the process of ammonification may function as a base for the neutralization of nitric acid formed during the later stages of nitrification. This question is dealt with further in a subsequent paper.

Plot.	Milligrammes of nitrogen fixed per gram of soil.	
	I.	II.
A	5·5	5·3
B	3·3	*
C	3·5	2·9
D	3·6	3·1
E	4·8	4·7
Blank	nil	nil

The results demonstrate clearly the existence of organisms of the type in question in the soils of the plots. The amounts of nitrogen fixed in the case of the soils of different plots are of similar order of magnitude, but the values found in the cases of plots A and E are higher than the remainder. Although there does not seem to be any very marked superiority in the activity of any of the different strains of bacteria growing in the soils of the various plots as evidenced by markedly greater fixation of nitrogen under the conditions of these experiments, it does not, on the other hand, seem unreasonable to suppose that the presence of an abundant food supply such as obtains in plots D and E will tend to an increase in numbers of the bacteria present and, consequently, to increased fixation of nitrogen. Moreover the open character of the soils of all the plots would be distinctly favourable to bacterial activity of this type.

It is admitted that the evidence presented in the foregoing pages would have been considerably strengthened if analytical data were available concerning the composition of the soils of the plots at the outset of the experiment. On the whole, however, the data adduced appear to strengthen the view, that under the conditions of the soil and climate obtaining on the cacao plots, very considerable accretions of nitrogen may occur as the result of the action of free nitrogen-fixing bacteria of the azotobacter type, and that the amount of nitrogen fixed may be very greatly increased in the presence of an ample supply of organic matter.

The question of the relations existing between the content of organic matter, the bacterial population, and the fertility of tropical soils is of much interest; owing to the high and equable temperature and, in many cases, the humid conditions, the various reactions are enabled to proceed with greater regularity and at a higher relative speed than under temperate conditions, which latter, it may be added, have governed almost entirely the bulk of the work hitherto performed in these directions.

Considerations such as these indicate that the Tropics present peculiar facilities for the investigation of certain soil problems, and it may be suggested that the further prosecution of the

* This result was lost.

study of such questions is likely to yield results of importance. and to facilitate the elucidation of many points which are at present obscure.

THE MOISTURE CONTENT OF THE SOILS OF THE PLOTS.

In order to ascertain whether the various forms of manurial treatment to which the plots of the original series of experiments had been subjected, had any appreciable effect on the moisture-retaining properties of the soils thereof, determinations of the moisture content of the soils of the various plots were conducted at intervals. In these determinations samples were drawn at regular intervals throughout each of the plots to a depth of 12 inches, by means of a soil auger, the individual samples immediately transferred to stopped jars and the moisture determined on each sample by drying to constant weight in a steam oven. The determinations were made by Mr. G. A. Jones, Assistant Curator of the Botanic Gardens, Dominica; the results are given in the table below; in every case the values given are the means of a series of determinations conducted on the soils of each plot. The results divide themselves into two series: the first performed on the soils of the original series of experiments, plots A to E, and covering a period ranging between March 1912 and January 1913; the second performed on the soils of the additional series of experiments, plots F to I, during the month of September 1913.

It is convenient to consider the values obtained in the two series separately, in the first instance.

MOISTURE CONTENT OF THE SOILS OF THE PLOTS.

Date.	Remarks.	A.	B.	C.	D.	E.
1912.						
March 26 ...	Rainfall, March 18 to 26, 4·55 ins.	19·7	20·8	19·59	22·25	25·05
April 22 ...	Rainfall, April 18 to 22, 1·74 ins.	17·7	17·7	14·18	20·99	22·41
May 13 ..	Rainfall, April 26 to May 13, 22 parts.	15·66	15·15	12·32	17·72	19·05
July 3 and 4	Rainfall, June 21, 3 ins. Since then, only a few parts.	17·05	15·02	13·98	18·03	20·00
1913.						
January 22	Fairly heavy rains since October. Rainfall January 1 to 22, 6 ins. 30 parts.	—	18·28	—	21·63	22·19

Date.	Remarks.	F.	G.	H.	I.
1913. September 8	Dry, hot weather, up to 7th instant. On Sept. 7, 0·62 in. fell.	19·40	20·15	19·70	17·25
Sept. 11 ...	No rain fell between Sept. 7 and 11.	18·26	19·85	17·25	16·48
Sept. 27 ...	Up to this date 3·66 ins. fell for the month, the distribution being even.	20·00	20·78	—	—

Dealing first with the results obtained on plots A to E, it will be seen that in every case the soil of the No Manure plot shows the lowest moisture content. From evidence produced as the result of the determination of the temperature of the soils of the various plots, it seems reasonable to conclude that this result is due to the higher average temperature of the soil of this plot attained during the day, which would tend to increase the loss of moisture. This is the result of the considerable amount of exposed soil surface resulting from the large number of trees which have died out and the generally poor growth made.

Of the other plots it will be seen that the highest moisture content is also shown by plot E, the next in order of magnitude being plot D. The moisture contents of plots A and B are always decidedly lower than those of plots D and E, and in general agree together fairly closely.

When the results are considered in correlation with the physical composition of the soils of the various plots, it will be seen that the relatively high retentivity of the soil of plot E is in agreement with the larger content of the fine soil particles, and to the somewhat lower level at which it is situated. Plot D closely approximates in physical composition to plot C, while plots A and B both contain appreciably larger amounts of the coarser grades of soil particles. The low moisture content of plot C has already been shown to be due to special causes; and while the relatively large amount of organic matter may possibly have increased the retentivity of the soil of plot D slightly, the difference between its moisture content and that of plots A and B does not exceed that which might be expected, in view of the somewhat finer texture of the soil and the slightly lower level of the plot.

This view is substantiated when the results obtained in relation to the soils of plots F, G, H, and I are considered. As already stated, these plots fall naturally into two pairs—F and G situated on level land, and H and I on a sloping hillside. In regard to situation and physical composition of the soil, the two members of each pair are almost identical in both cases.

It will be seen that in all cases the water contents of plots F and G are close together, but that the value shown by plot G, which was manured with cotton seed meal, is slightly higher than that of plot F, which was mulched.

In regard to plots H and I, the moisture content as determined show a slightly larger divergence, though the difference observed is not very large. In both instances, however, the moisture content of the mulched plot I is slightly lower than that of the No Manure plot H.

The conclusion appears to be indicated, therefore, that while adequate shading and covering of the surface will naturally affect the moisture content of the upper layers of the soil under the conditions governing these experiments, none of the manurial methods practised exert an effect of any appreciable magnitude on the retentivity of the soil, even when moderately large amounts of organic material are applied, as in the case of plots D, F, and I.

On the other hand, it must not be overlooked that the thick covering of fallen leaves characteristic of a well-grown cacao orchard probably exerts a considerable effect in assisting to conserve the moisture of the soil and checking surface evaporation.

On soils heavier in type than those of these plots it is to be expected that heavy dressings of organic manure will produce a larger effect in modifying the retentivity that has been seen in the present instance.

The Investigation of the Temperature of the Soils of the Plots.

In habit, the cacao plant is characteristically delicate and may be expected to be especially sensitive to any markedly great fluctuations of soil temperature.

Accordingly, a series of systematic observations of the temperatures of the soils of the plots was conducted during the years 1912 and 1913. The temperatures were taken by means of soil thermometers at a series of points evenly distributed throughout each of the plots, and the determinations were made at depths of 6, 12, and 18 inches, respectively. The measurements were made at various seasons of the year and during different times of the day.

In the case of plot C, the measurements were made on both shaded and exposed portions of the plot; in the remaining instances the points at which the determinations were made were fully shaded by the trees.

The results for each series of determinations are given in tabular form below, together with the dates on which the measurements were made and other correlated data of interest in this connexion.

As in the case of the soil moisture determinations, Mr. G. A. Jones is responsible for the majority of results recorded.

The data compiled, afford a considerable mass of information concerning the temperature of the soils under the conditions of these experiments, covering approximately the range of seasonal conditions throughout the year.

They demonstrate that under the conditions in question, the soil temperature of the shaded portions of each of the plots varies but little throughout the day and remains fairly constantly around the value for the air temperature during the coolest

portions of the day. No actual records exist of night temperatures, but as many of the readings were taken in the early morning, and as during the heat of the day the values recorded show very little rise above the morning values, the inference seems legitimate that during the night the temperature does not fall to any appreciable extent below the day values.

The most extensive series of readings is that given in respect of plots A to E on September 3, 1913, which in one day included readings taken in the early morning, at noon, and in the evening. Examination of the values reveals the striking fact that with the exception of the readings taken on the unshaded portions of plot C, the total variation among the whole of the readings is less than one degree Centigrade.

In the entire series of readings the lowest values recorded are those obtained on January 22, 1913, during particularly cool showery weather, when the readings ranged from 21·5° C. to 22·5° C. If this series of readings is excluded, the maximum variation between the whole of the readings taken on the shaded portions of the plots is only 2·1° C.; while if they are included the maximum temperature range is 3·7°C., the highest temperature recorded being 25·2°C. and the lowest 21·5°C. It is moreover noteworthy that the readings obtained are in all cases practically uniform to a depth of 18 inches.

On the other hand, the readings obtained on the unshaded portions of plot C show much greater variation. The actual range of temperatures recorded lies between 23·3°C. and 29·6°C., while the temperature of the upper 6 inches of soil often diverges to quite a marked degree from that of the lower succeeding layers, being markedly hotter or cooler, according to the time of day.

The main series of data produced relate to plots A to E; the additional measurements in respect of plots F to I collected during September 1913, supplement these but call for no special comment, since they fully confirm the set of values obtained in respect of the original series.

It is evident from the foregoing that, under the conditions governing these experiments, a very equable soil temperature is maintained when the cacao trees are well grown and the ground is adequately shaded; in assisting to maintain this, the thick covering of fallen leaves characteristic of a well-grown cacao orchard is no doubt of the highest importance.

While none of the methods of manurial treatment followed appear to influence the soil temperature to any appreciable extent, nevertheless adequate supplies of plant food and the prevalence of soil conditions favourable to growth are of the utmost importance, since it is only when these are present that the conditions of fully shaded soil can obtain, on which the maintenance of an equable soil temperature depends.

The delicate character of the cacao plant has already been touched on, and its consequent probable sensitiveness to changes of temperature. In this connexion, the above results also indicate the value which temporary shade has in young cacao plantations by protecting the soil and assisting to maintain an equable soil temperature favourable to the development of the young cacao plants.

SOIL TEMPERATURES OF THE PLOTS.

Date. 1912.	Remarks.		A. 6"	A. 12"	A. 18"		B. 6"	B. 12"	B. 18"		C. 6"	C. 12"	C. 18"		D. 6"	D. 12"	D. 18"		E. 6"	E. 12"	E. 18"
April 30	Rainfall previous 14 days roughly 2 inches. Taken 9 to 11 a.m.	(a)	23·4	23·2	23·1	(a)	23·5	23·4	23·2	(a)	23·4	23·2	23·2	(a)	25·0	24·0	23·1	(a)	24·0	23·5	23·2
		(b)	23·9	23·9	24·0	(b)	23·5	23·4	23·4	(b)	24·0	23·7	23·7	(b)	24·5	24·0	23·6	(b)	23·8	23·6	23·2
								[Exposed			28·0	27·7	26·5]								
May 13	Rainfall previous 14 days nil 6 30 to 10 30 a.m.	(a)	24·6	24·6	24·6	(a)	24·0	24·0	24·0	(a)	23·6	23·6	23·6	(a)	23·2	23·5	23·5	(a)	23·9	24·0	24·0
		(b)	24·0	24·0	24·0	(b)	24·0	24·0	24·0	(b)	24·2	24·2	24·1	(b)	24·0	24·0	23·7	(b)	24·0	23·9	23·8
								[Exposed			22·1	23·0	22·1]								
July 2	A dull day, no rain, no sun, 2 30 p.m. to 5.30 p.m Office temperature 30° C.	(a)	25·0	25·0	25·0	(a)	24·9	24·3	24·[illegible]	(a)	24·8	24·4	24·7	(a)	25·0	25·0	24·8	(a)	24·8	24·4	24·5
		(b)	25·0	24·8	24·5	(b)	24·9	24·6	24·6	(b)	25·2	24·8	24·9	(b)	24·9	25·0	24·7	(b)	25·0	24·9	24·3
								[Exposed			28·1	27·0	27·0]								
July 3	Early morning readings practically no rain during night. Office temperature 24° C. 5.30 a.m. to 8.30 a.m	(a)	24·2	24·5	24·2	(a)	24·0	24·2	24·0	(a)	24·0	24·1	24·1	(a)	24·0	24·0	2·40	(a)	24·0	24·0	24·1
		(b)	24·7	24·9	24·9	(b)	24·0	24·4	24·5	(b)	24·2	24·6	24·5	(b)	24·0	24·2	24·2	(b)	24·0	24·0	24·0
								[Exposed			26·2	27·0	26·5]								
July 3	Taken at 5 p.m. after hot sunny day.		25·0	24·5	24·5		24·9	24·9	24·5		25·3	24·8	24·5		24·7	24·5	24·4		24·3	24·2	24·4
								[Exposed			28·1	27·0	26·8]								

SOIL TEMPERATURES OF THE PLOTS.—*Concluded.*

Date. 1913	Remarks.		A. 6″	A. 12″	A. 18″	B. 6″	B. 12″	B. 18″	C. 6″	C. 12″	C. 18″	D. 6″	D. 12″	D. 18″	E. 6″	E. 12″	E. 18″
Jan. 22 ...	Taken at 7 a.m. during dull showery weather, Air temperature 7 a.m., 21° C.		(a) 22·0	22.2	22·4	(a) 22·0	22·0	22·4	(a) 21·8	22·0	22·2	(a) 21·5	22·0	22 3	(a) 22·0	22·2	22·5
			(b) 22·6	22.9	23·0	(b) 22·0	22·1	22 2	(b) 22·0	22·2	22·5	(b) 21·9	22·1	22·5	(b) 21·7	22·2	22·3
							[Ex	posed	23·3	23·8	24·4]						
June 1 ...	Taken 5.30 a.m. to 9 a.m.		(a) 24·2	24·2	24·2	(a) 24·1	24·1	24·1	(a) 24·2	24·0	24·0	(a) 24·0	24·0	24·2	(a) 24·1	24·1	24·0
	Temp. 5.30 23° C. Temp. 9 a.m. 26° C. Rainfall previous 14 days 75 parts.		(b) 24·6	24·8	24·8	(b) 24·0	24·1	24·0	(b) 24·3	24·5	24·2	(b) 24·2	24·2	24·5	(b) 24·0	24·2	24·0
Sept. 3 ...	Three series of determinations taken on the early morning, at noon, and in the evening respectively. Weather hot and dry. Air temperature, morning 24·2° C., noon 29·2° C., evening 27·0°	morning					[Ex	posed	26·1	26·0	26·2]						
		morning	(a) 24·2	24·3	24·3	(a) 24·2	24·2	24 2	(a) 24·3	24·[illegible]	24·2	(a) 24·3	24·0	24·0	(a) 24·2	24·2	24·2
		morning	(b) 24·6	25·0	24·8	(b) 24·2	24·4	24·4	(b) 24 8	24·8	24·6	(b) 24·2	24·2	24·2	(b) 24·3	24·4	24·1
		noon	(a) 24·7	24·5	24·4	(a) 24·6	24·4	24·4	(a) 26·4	27·0	26·8	(a) 24·5	24·3	24·1	(a) 24·6	24·4	24·4
		noon							25 0	24·6	24·4						
		noon	(b) 25·4	25·3	25·0	(b) 24·8	24·6	24 5	(b) 25·1	25·1	24·9	(b) 24·4	24·3	24·3	(b) 24·5	24·5	24·3
		evening					[Ex	posed	29·6	27·2	26·8]						
		evening	(a) 24·8	24·5	24·4	(a) 25·0	24·6	24·4	(a) 25·1	24·6	24·5	(a) 24·8	24·4	24·2	(a) 25·0	24·4	24·2
		evening	(b) 25·5	25·1	25·0	(b) 25·0	24·6	24·4	(b) 25·9	24·9	24·8	(b) 24·9	24·3	24·2	(b) 24·5	24·4	24·3
		evening					[Ex	posed	29·6	27·2	26·8]						

Date.	Remarks.		F.			G.			H.			I.		
1913			6″	12″	18″	6″	12″	18″	6″	12″	18″	6″	12″	18″
Sept. 4	These series of determinatious taken in early morning	morning (a)	24·6	24·6	24·5	24·5	24·5	24·5	24·9	25·0	25·0†	24·1	24·2	24·3
		morning (b)	—	—	—	—	—	—	24·0	24·3	24·2*	24·8	24·8	24·7§
	and in the evening respectively.	evening (a)	25·2	24·6	24·6	25·0	24·6	24·6	26·0	25·2	25·2	24·8	24·6	24·6
	Air temperatures,	evening (b)	—	—	—	—	—	—	25·0	24·5	24·4	25·4	25·0	25·0
	Morning 24·6°C.													
	Evening 27·1°C.													

† Lies at top end of control plot and is comparable with (b) of mulch plot.
§ Lies at the top of the plot and has no great accummulation of mulch
* Has a thick covering of cacao leaves from a tree.

The Relations Existing Between the Annual Yields of Cacao and the Rainfall.

The rainfall for each year during which these experiments have been in progress has already been given on page 87. The study of the correlation between the rainfall and the yields of cacao is of interest, but while the broad general dependence of the crop on this factor is obvious, nevertheless other agencies such as relative atmospheric humidity, daily temperature range, and wind pressure also exert a sensible effect on the yield.

Cacao is naturally a delicate plant (although some varieties are more hardy than others) and is peculiarly susceptible to unfavourable conditions; moreover the habit of flowering is distinct and characteristic, while the proportion of the total number of flowers set, which ultimately develop into mature fruit is very low. On these accounts, factors which would be of relatively small importance in relation to hardier plants may be effective in producing considerable variations in the case of cacao and so tend to mask the effects of variations of rainfall.

A factor of prime importance in relation to annual precipitation is the distribution, and in this connexion the employment of the factor for the calculation of the effective rainfall is of considerable value.*

In Dominica, it is true, the rainfall is as a rule very similarly distributed each year, so that in general, in this particular case, the effective rainfall follows the actual rainfall very fairly closely. In less favoured situations however, the divergence between the two factors may be very marked from year to year.

Cacao picking is in progress practically throughout the year, but the largest proportion of the crop is picked during the months of October, November and December, and March and April respectively, the two seasons being known as the Christmas crop and the Carême crop.

In these records the cacao year is taken as terminating on June 30, as at this date practically no cacao is being reaped. This system avoids complications as the result of the lateness or earliness of either crop. Under other modes of reckoning, this cause may lead to returns which properly belong to one season being carried over into the next.

It has already been pointed out that in a system of manuring such as is applied to these plots, a period of several years' duration is required to elapse before the trees settle down to the state of productiveness conditioned by the manurial treatment applied; this fact consequently tends to obscure any attempt to correlate the yields of the plots with the rainfall in the earlier years of the experiments, except in the case of that receiving no manure.

---

*The effective rainfall is given by the following formula :—

$$R' = R\frac{t'}{t}$$

R is the total rainfall over any period
R' effective ,, ,, ,, ,,
t is the total number of days in the period
t' is the number of days on which rain fell during the period.

PLATE III.

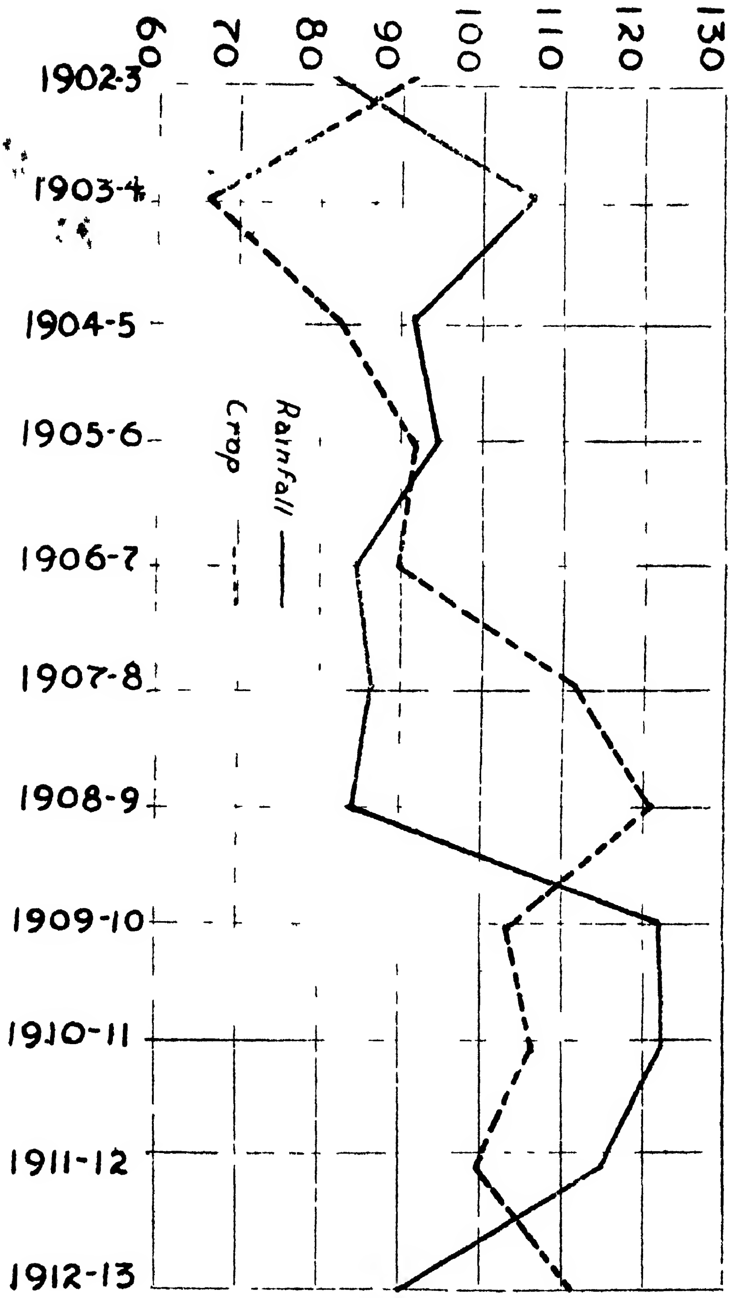
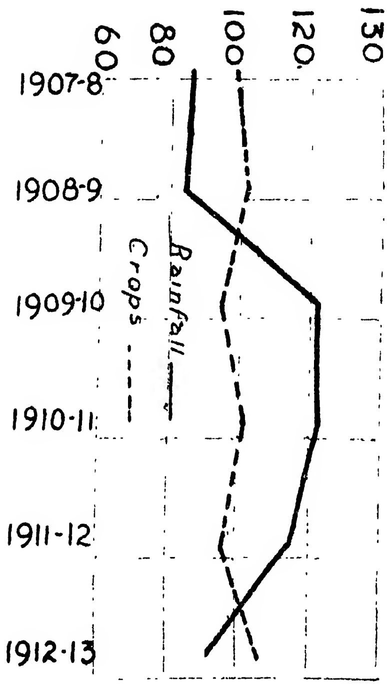

60
70
80
90
100
110
120
130
1902-3
1903-4
1904-5
1905-6
1906-7
1907-8
1908-9
1909-10
1910-11
1911-12
1912-13
Crop
Rainfall

PLATE IV.


60
80
100
120
130
1907-8
1908-9
1909-10
1910-11
1911-12
1912-13
Rainfall
Crops

In the following table are given columns showing the effective rainfall for the entire year, and for the periods July to December and January to June, for each year during which these experiments have been in progress, expressed as a percentage of the average total effective rainfall during the entire period; while additional columns also give the yield per acre of the No Manure plot (plot C) for each year and half-year, expressed as a percentage of the average total yield for the entire period: the results are also displayed graphically in Plates III and IV.

A similar set of data is also given below for the mean returns of the series A to E during the period of 1907-8 to 1912-13, between which dates the plots appear to have settled down to a state of uniform productiveness. These results are also displayed graphically in Plates V and VI.

Surveying the results, it is at once perceived that the crop reaped during the period January to June, on the average, considerably exceeds that yielded between July and December, while, on the other hand, the rainfall for the latter period is much greater than for the former. As was anticipated, notable secular variations in yield are to be observed, which are not apparently directly traceable to rainfall; but, on the whole, a distinct correspondence does appear to exist between the rainfall and the crop.

The general impression given is that, when the total effective rainfall exceeds the average value by a large amount, the tendency is for the effect to be seen in diminished yields. On the other hand, during the period covered by the trials, the rainfall does not seem at any time to have fallen so low as to cause a diminution in yield by reason of deficiency.

When the results for the half-yearly periods are examined, several further points of interest stand out. The rainfall during the July-December period is always considerable and usually largely exceeds that of the January-June period. The figures lead one to infer that the high precipitation between July and December limits the productivity during that term and causes the so-called Christmas crop to maintain a roughly constant value. Excessive rainfall during the same period, moreover, appears to exert an unfavourable influence on the crop reaped between the succeeding January and June. The return during this period also seems to be influenced considerably by the precipitation occurring during the time it is being matured and harvested. As stated above, this is normally much lower than in the later months of the year, and a relatively high rainfall between the months of January and June is usually followed by an increased return during this period. It has already been pointed out that the yields are also liable to be affected by a variety of other causes, and on this account the correlation to be observed between the rainfall and the yield is only approximate. It is hoped that in future years the rainfall returns may be supplemented by other meteorological data, which may serve to shed additional light on this question.

Year.	Rainfall.			Yield per acre of No Manure plot (plot C).		
	Effective rainfall for entire year. Per cent. of av. for 11 years.	Percentage total average effective rainfall. July to Dec.	Percentage total average effective rainfall. Jan. to June.	Total yield for entire year. Per cent. of av. for 11 years.	Percentage of average total yield. July to Dec.	Percentage of average total yield. Jan. to June.
1902-3	82·8	61·3	21·5	94·2	56·3	37·9
1903-4	108·0	81·6	26·4	68·4	19·0	49·4
1904-5	93·9	65·8	28·1	83·9	40·3	43·6
1905-6	96·1	68·5	27·6	93·3	46·5	46·8
1906-7	86·1	61·4	24·7	91·0	36·5	54·5
1907-8	87·8	66·6	21·2	112·6	40·3	72·3
1908-9	85·2	50·3	34·9	122·1	49·3	72·8
1909-10	123·3	70·7	52·6	104·4	48·6	60·8
1910-11	123·1	70·7	52·4	107·1	45·5	61·6
1911-12	115·5	83·8	31·7	100·1	45·1	55·0
1912-13	90·2	53·3	36·9	111·4	56·7	54·7

Table showing mean returns of the series A to E during the period 1907-8 to 1912-13.

Year.	Rainfall.			Yield per acre.		
	Effective rainfall for entire year. Per cent. of av. for 6 years.	Percentage total average effective rainfall. July to Dec.	Percentage total average effective rainfall. Jan. to June.	Total yield for entire year. Per cent. of av. for 6 years.	Percentage of average total yield. July to Dec.	Percentage of average total yield. Jan. to June.
1907-8	87·8	66·6	21·2	100·5	40·3	60·2
1908-9	85·2	50·3	34·9	103·3	46·0	57·3
1909-10	123 3	70·7	52·6	94·9	42·4	52·5
1910-11	123·1	70·7	52·4	100·9	44·9	56·0
1911-12	115·5	83·8	31·7	95·0	48·7	46·3
1912-13	90·2	53·3	36·9	105·4	51·9	53·4

PLATE VI.

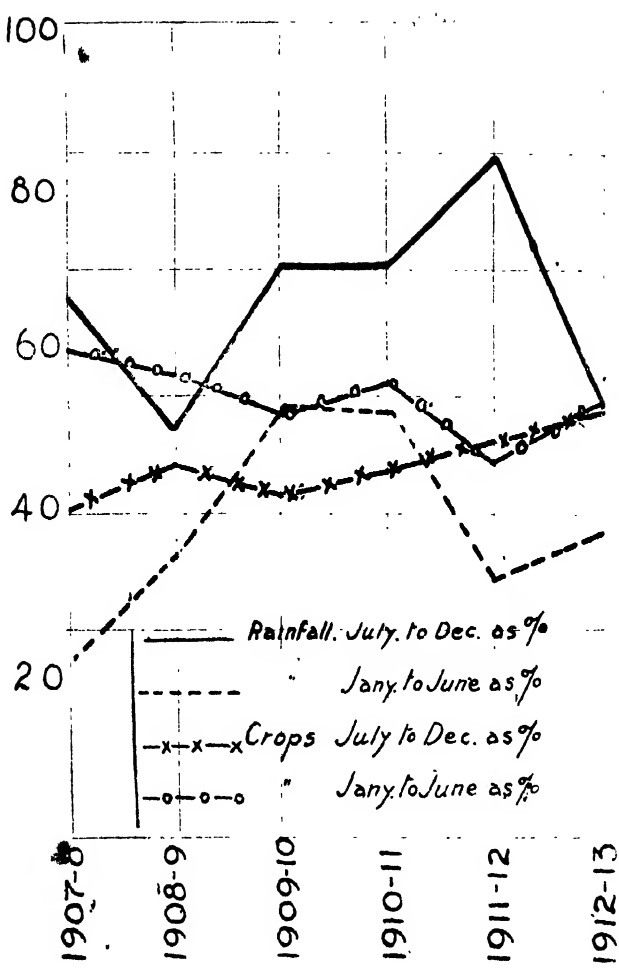
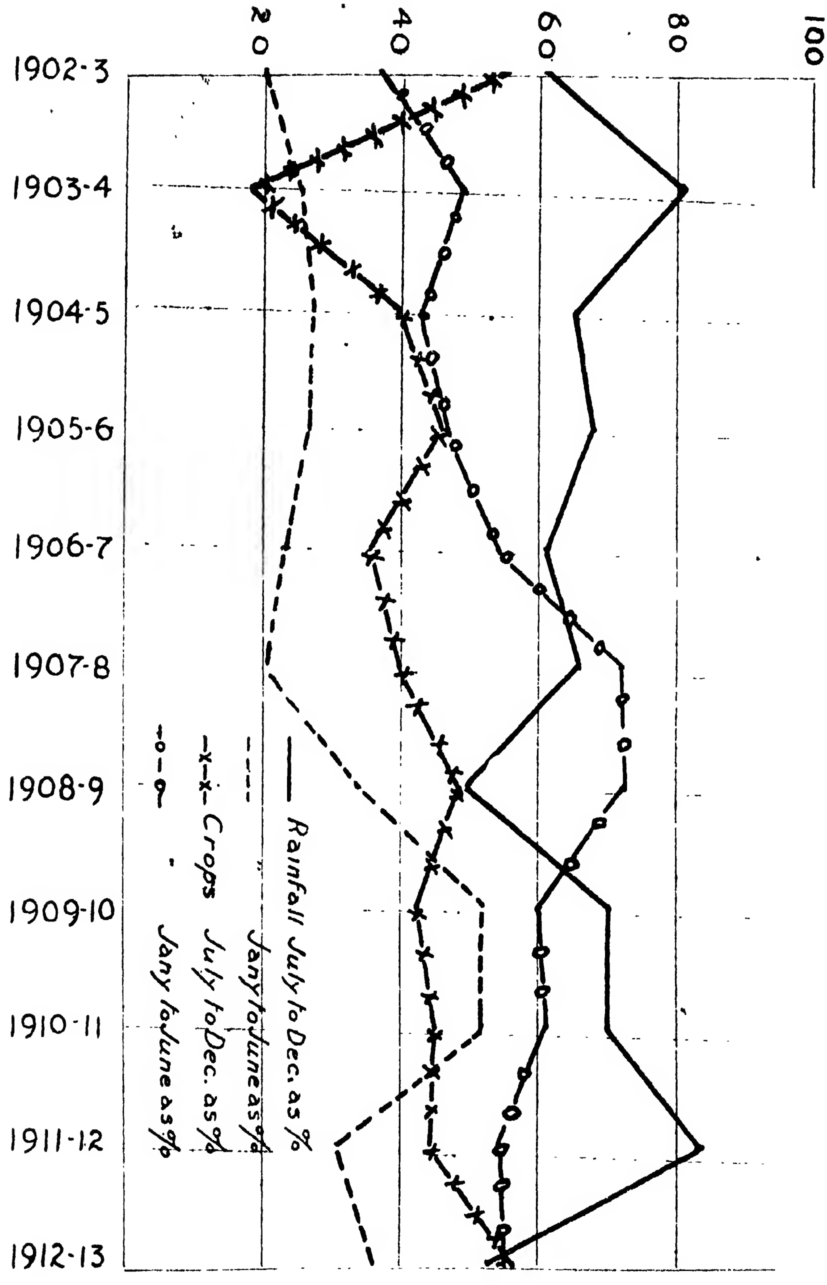

100
80
60
40
20
Rainfall. July. to Dec. as %
" Jany. to June as %
Crops July to Dec. as %
" Jany. to June as %
1907-8
1908-9
1909-10
1910-11
1911-12
1912-13

PLATE V.



20
40
60
80
100
1902-3
1903-4
1904-5
1905-6
1906-7
1907-8
1908-9
1909-10
1910-11
1911-12
1912-13
Rainfall July to Dec. as %
" Jany to June as %
Crops July to Dec. as %
" Jany to June as %

EXPLANATION OF PLATES.

Plate I, Showing yield of original series of Cacao Manurial Experiments, Dominica, in pounds of cured Cacao per acre.

Plate II, Showing yield of additional series of Cacao Manurial Experiments, Dominica, in pounds of cured Cacao per acre.

Plate III, Effective Annual Rainfall expressed as a percentage of the average rainfall. Annual Yield of the No Manure Plot expressed as a percentage of the average yield.

Plate IV, Effective Annual Rainfall expressed as a percentage of the average rainfall. Mean Annual yield of of Plots A to E expressed as a percentage of the average yield for the entire period.

Plate V, Effective Rainfall July to December expressed as a percentage of the average rainfall.

Effective Rainfall January to June expressed as a percentage of the average rainfall.

Yield of the No Manure Plot C, July to December, expressed as a percentage of the average total yield of the plot.

Yield of the No Manure Plot C, January to June, expressed as a percentage of the averag total yield of the plot.

Plate VI, Effective Rainfall, July to December expressed as a percentage of the total average rainfall.

Effective Rainfall January to June expressed as a percentage of the total average rainfall.

Crop total July to December expressed as a percentage of the average total crop.

Crop January to June expressed as a percentage of the average total crop.

APPENDIX.

THE MANURIAL COMPOSITION OF MATERIALS USED FOR MULCHING.

The importance attaching to the mulching method of manurial cultivation has prompted the collection of data regarding the manurial components contained in different types of material such as is likely to be employed in this process in actual practice. The data collected are summarized in the subjoined table, which gives in terms of percentages on air-dried material the amount of the different manurial constituents contained in each.

It will be seen that the class of material varies within wide limits, while the actual manurial value also differs markedly in individual instances. The high nitrogen content shown by Saman pods and the gliricidia clippings demonstrates clearly the manner in which leguminous material will tend to enrich mulches in this particular constituent, and throws interesting additional light on the results quoted in the body of the paper in relation to the mulch plots.

MANURIAL COMPOSITION ON AIR-DRY MATERIAL.

Constituent.	Hay grass (*Andropogon caricosus*).	Lemon grass (*Cymbopogon citratis*).	Mixed grass (cut from hillside at B. Station, Dominica).	Grass used for mulch at Picard, Dominica (See *W.I.B.* Vol. VII, p. 211).	Clippings from *Gliricidia maculata*.	Pods of *Pithecolobium Saman*.
Moisture @ 100° C. ...	13·42	13·03	9·97	10·83	11·69	16·8
Nitrogen	0·66	0·51	0·83	0·74	3·12	2·60
Phosphoric acid ...	0·04	0·37	0·22	0·22	0·40	—
Potash	0·97	1·16	0·80	0·99	—	—

SUMMARY.

In the foregoing paper the following points are dealt with in relation to cacao manurial experiment plots at the Botanic Station, Dominica

2. The plots consist of two series, an original series consisting of five numbers, and subsidiary series containing four additional plots. The original series has been continuously carried on since 1802, and the additional series since 1906.

3. The manurial treatments applied comprise applications of nitrogen, phosphate, and potash alone and in conjunction with

one another, and trials with the application of heavy mulches; the mulching material used consists of leaves and grass mixed with pods of the Saman tree.

4 Physical analyses are given showing the composition of the soils of the plots in the original series; they comprise a series of sandy loam which tends to get heavier as one proceeds down the plots from A to E. Local variations in physical constitution are further illustrated by shrinkage determinations performed on samples taken at regular intervals throughout the plots.

5. The annual yields from each of the plots are recorded; they show the influence of the various manurial applications to a marked degree; the largest increases are regularly shown by those plots which have been mulched; the next largest increases are shown by the plot which has received a complete manuring. A survey of the results for the entire period of years shows that in orchard cultivation under the conditions governing these experiments, it takes from three to five years for the trees to settle down to the state of productivity conditioned by the particular form of manurial application.

6. Data are given showing the mean probable error attaching to the various experiments, and demonstrating that the value of this factor is in all cases of such magnitude as to allow of the results adduced being regarded with confidence as indicative of real differences derived from various forms of treatment.

7. Analyses have been made of the soils of the different plots from the point of view of chemical constituents. The results show the effects of the various manurial applications on the composition of the soil.

8. Values are also given for the gains accruing to the plots with the different manures, while analytical data are put forward showing the amounts of fertilizing constituents removed in the crop.

9. Comparison of these data in respect of the nitrogen content of the soils of the plots reveals the fact that on a comparison of the gains and the losses, the soils of certain plots, and notably those which have been mulched with grass and leaves, show considerable accretions to the nitrogen content which are unaccounted for by the quantities of this constituent added in the manurial application.

10. The suggestion is made that these accretions are due to the action of free nitrogen-fixing bacteria of the azotobacter type; evidence is given proving the existence of this type of organisms in the soils of each of the plots of the original series.

11. An account is given of certain investigations of the changes occurring when the soils of the plots are kept in the Laboratory in a moistened condition. It was found that the humus content of the soils tended to diminish very rapidly under these conditions; the nitrogen content, on the other hand, did not tend to fall off in the same way as a rule, while an appreciable amount of nitrification always took place. This latter result was somewhat unexpected, in view of the small content of calcium carbonate contained in the soils of the plots, and the suggestion is made that the ammonia formed in the early stages of ammonia

APPLIANCE IN ANTIGUA FOR SPRAYING CATTLE AGAINST TICKS.

APPLIANCE IN ANTIGUA FOR SPRAYING CATTLE AGAINST TICKS.—CATTLE PASSING THROUGH.

fication may function as a base to neutralize the nitric acid produced in the latter stages of the process.

12. The results include a study of the soil moisture conditions obtaining on each of the plots; the results, on the whole, indicate that while adequate covering and shading of the soil surface affect the moisture content of the upper layers of the soil to a marked degree, none of the manurial methods practised have exerted any appreciable direct effect on the moisture-retaining properties of the soils of the plots.

13. Investigation was also made of the temperature of the soils of the plots at different times of the day and different seasons of the year. The results show that when the soils of the plots are adequately shaded, the soil temperature remains very nearly constant at the value of the air temperature during the coolest portions of the day; when adequate shading is absent, however, the soil temperature varies to a much greater extent, and in view of the delicate character of the cacao plant, the results emphasize the utility of shade in young cacao orchards.

14. In the concluding portion of the paper the relations between the annual rainfall and the yields of cacao from the plots are considered.

15. An appendix gives analytical information regarding the manurial constitution of various materials used for mulching.

In conclusion, acknowledgement must be made of assistance rendered by Messrs. V. M. Weil, B.Sc., and R. E. Kelsick respectively, senior and junior assistants in the Government Laboratory for the Leeward Islands, in relation to the analytical work referred to in the body of this paper; while the part borne by Mr. G. A. Jones, Assistant Curator of the Botanic Station, Dominica, in carrying out certain portions of the investigations described, has already been referred to.

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THE 'TRI-TRI' OR WEST INDIAN WHITEBAIT IN ST. VINCENT.

BY W. N. SANDS, F.L.S.,

Agricultural Superintendent, St. Vincent.

The 'tri-tri' or West Indian whitebait (*Sicydium plumieri*) is an important food fish in St. Vincent, Dominica, and possibly other islands where there are clear, fast-running mountain streams.

In the *Agricultural News*, Vol. IV, No. 83, p. 187, there was published an interesting account of the fish and its habits in St. Vincent; this was taken from an article contributed to the *American Naturalist* by Mr. Austin H. Clark, of the Smithsonian Institution.

The adult fish inhabit the mountain streams of both the Leeward and Windward districts of St. Vincent. Clark gives a good description of them as follows:—

'They [the fish] are usually observed lying motionless on the sandy bottom of pools, head up stream. They will lie in one position for a long while, then, with a sudden jerk, move to another place. If disturbed, they dart quickly under the overhanging banks, or under rocks or logs in the stream. When seen on a sandy bottom, the colour of these fishes is a very light brownish gray, with seven or eight transverse bands of darker. If over dead leaves, or on darker masses of rock, they are violet brown, the transverse bands being nearly black. They harmonize so well with their surroundings that they are distinguishable by a careful examination only. The adults measure from $3\frac{1}{2}$ to $4\frac{1}{2}$ inches in length. In the waters where this fish occurs there is a small slender crayfish, of the same size and colour, which is very easily mistaken for it. This crustacean has the same habit of lying for a long while in one position, then suddenly moving to another, and, if disturbed, takes refuge under the banks or under stones in the same way. They may usually be distinguished by the fact that they move tail first, and then occasionally crawl slowly on the bottom; they also are much commoner near the sources of the rivers, above the range of the "tri-tri."

'In the dry season the adult "tri-tri" migrate down stream to the sea, where they lay their eggs, probably near the mouths of the rivers from which they descended, and then apparently die, as no adult fish are ever seen to return.

'The young fry when about $\frac{3}{4}$- to $1\frac{1}{4}$ inches in length, ascend the rivers by thousands during the wet season (August, September and October), moving up stream in a continuous line near or under the banks, as do the young of eels (Anguilla). When in a stretch of comparatively quiet water they move steadily onward; but in rapid water they progress by jerks, resting on the bottom for a few seconds, then making a fresh dash onwards and taking a fresh grip on a pebble or rock with the central sucker, and after remaining quiet for a few seconds, dashing on again. They even ascend vertical or overhanging surfaces, over which a small amount of water is running; in this way, resting for a while, then

TRI-TRI or West Indian Whitebait (*Sicydium plumieri*) St. Vincent. ($\frac{1}{2}$ natural size).

TRI - TRI (*Sicydium plumieri*) ascending perpendicular wall of a dam. St. Vincent.

moving upward an inch or so, resting again and moving on. Sometimes during one of these ascents they are swept off and into the eddy below; but in a few minutes they are ready to try again. I have seen as many as a dozen moving up the face of a rounded rock a foot in diameter, over which the flow of water was not enough to cover their bodies. After a heavy rain the waters of the St. Vincent rivers rise rapidly, and then fall again, leaving many little outlying pools along the banks, which under the influence of the scorching tropical sun soon dry up, leaving dusty hollows. Many of the fishes become cut off from the main stream at such times, and, as the pools dry up may be seen jumping about in the hollows, entirely covered with a thick coating of dust. If these stranded individuals be placed again in the main stream they soon begin to ascend with the others as if nothing had happened. The tenacity of life of the young "tri-tri" is remarkable. They will live for several hours in these dry situations, exposed to the full rays of the sun.

'On reaching the pools at the higher altitudes the fish select some suitable spot and there remain until maturity, when they return to the sea to deposit their eggs. I was unable to ascertain just how long this period was.'

During their ascent of the streams, and usually near the mouths of the rivers, large quantities of the young are caught for human consumption. The chief method of capture is by means of a white sheet weighted with a large number of small stones and sunk to the bed of the stream just inside the surf. The sheet is put down in the evening and lifted about 5 a.m. with the 'tri-tri' that have collected on and under the stones. In quiet places further, but smaller, captures can be made later on in the day; however, the early morning is the most favoured time for the work.

It is local tradition of the peasantry that 'sheet' lightning in some way or other acts as an incentive to the 'tri-tri' to leave the sea and ascend the rivers. This form of electrical display is, therefore, commonly called 'tri tri' lightning.

The photograph, Plate I, taken at 10 a.m. by the writer shows a column of 'tri-tri' actively ascending the perpendicular wall of a dam built across a stream to supply water for power purposes for an arrowroot mill. Part of the outlet pipe of the dam is seen at the bottom of the picture and water escaping under great pressure, the dam being full. The pressure was so strong that the 'tri-tri' on reaching the pipe could not pass through; therefore, in order to continue their journey it was necessary for them to climb the wall. This they did successfully with the aid of a small trickle of overflow water. The photograph affords abundant evidence of the fact that no obstacle however great impedes the progress of the fish on their way up stream, provided the surface of the obstruction is wet.

The fish are limpid when caught at the mouths of the rivers fresh from the sea. After a few days in the rivers they become much darker in colour and are then not so palatable.

The fish to be seen in the photograph, Plate II, were captured about ½- mile from the sea climbing the wall of the dam shown in Plate I; the smaller specimens measured ⅞-inch and the

larger 1⅜ inches in length. These latter had no doubt been in the river a longer period and made a much slower ascent.

In season the fish are exposed for sale in large quantities in the markets of the local towns and are sold either by the measure or by the pound.

The chief way in which they are prepared for the table is in the form of cakes, but they are also eaten boiled (whole) or 'devilled'.

SPRAYING FOR CONTROL OF TICKS IN ANTIGUA.

BY P. T. SAUNDERS, M.R.C.V.S.,

Veterinary Officer on the Staff of the Imperial Department of Agriculture for the West Indies.

The question of ticks and their eradication is one that has played an important part in the economy of the stock industry in the West Indies for many years. It is feared, however, that in many islands no attempt has been made to deal with the question in an efficient manner, and, as a natural consequence, the tick has always had, more or less, the upper hand in the struggle. The usual method employed, at least in the smaller islands of the West Indies, of 'ticking' animals, is to scrape the ticks off with a knife or to pull them off with the fingers, the parts being afterwards washed with a weak solution of Jeyes fluid, or similar agent.

It will be evident that such a procedure, though undoubtedly lessening the number of ticks, is yet wanting in thoroughness. The small larval or 'seed' ticks are often missed in the scraping, and are not thoroughly dressed with the agent employed owing to the presence of the hair, the result being that they develop normally and the life cycle is repeated. It is not the common practice to wash the animal all over, but only those parts where ticks are most frequent, and many escape the dressing in this way. In Antigua the Gold Tick (*Amblyomma variegatum*) is further cause of trouble in that the proboscis is firmly fixed in the skin, and when the tick is pulled or scraped off, either the proboscis pulls out a small piece of skin attached to it, or it remains in the skin, with the result that, in either case, a festering sore is often produced.

In a bad tick season, the effect on the animals is very marked from the anæmia consequent upon the mechanical loss of blood from the sucking of the ticks, and many flocks look poor and miserable from their effects. Diseases may also be propagated through the agency of ticks; so there at once appears every argument for their systematic eradication.

This conclusion was forced upon the representatives of Messrs. Henckell DuBuisson & Co., and the firm imported a spraying machine to deal with the flocks of cattle used on the company's estates.

This machine was erected at Tomlinsons, as a convenient centre, in March 1913, and after nearly twelve months' trial, it

is gratifying to be able to record an entire satisfaction both in its working and in its results.

It may be of interest to give particulars as to the nature and cost of erection of the machine and the necessary pens, with a view to the guidance of those owners who consider the matter worthy of close attention.

The total size of the pen is 84 feet by 74 feet, with fencing 5 feet 8 inches high. This is divided into two equal halves, one constituting the receiving pen and the other the drying pen. The intervening fence serves to keep the two herds, i.e., the sprayed and the unsprayed, separate.

The machine has an 'entrance race' 13 feet long leading to it, and an 'exit race' 15 feet long leading from it.

In the corner of the receiving pen nearest to the 'entrance race' is a 'crush pen' 43 feet by 20 feet. Both the entrance race and the exit race have sloping sides and are 1 foot wide at the bottom, widening to 3½ feet at the top, the object of this being to prevent animals from turning round.

The entrance race (see Fig. 2), which is floored with cement, has holes in both sides at the height of an animal's chest, through which bars may be put in order to keep back animals, if required, and which may also be used to prevent stubborn animals from backing out.

The machine itself is of galvanized iron 12 feet long, and is 1 foot wide at the foot boards, which are across the floor, increasing to 3 feet 6 inches at its greatest width, and is 6 feet high. (See Fig. 1.) The dip is administered by means of atomizing nozzles, in the form of a spray from pipes which run round the inside of the machine. The nozzles give a fine fan-shaped spray, and they are set from the pipes at various angles, ingeniously contrived so as to fill the interior of the machine with a cloud of spray, which is so efficient that it will thoroughly soak an animal which passes through it in a very few seconds.

The surplus dip drains through the floor of the machine, through strainers of fine-meshed brass wire gauze, into the tank, and is used again. Some little difficulty is occasionally experienced by dirt and débris, especially from the feet of animals, finding a way into the tank, when it may have the effect of stopping the nozzles: this, however, is easily remedied, and at most causes little delay. The dip is pumped from a tank at the side of the machine, by means of a pump which requires the efforts of two men to keep up a constant high-pressure spray. This tank is of galvanized iron and has a gauge to indicate the amount of dip contained.

The floor of the pen is partly rock and partly earth, and is kept free of vegetation. The necessity for this is, of course, obvious in the drying pen where the floor may become saturated with the arsenic solution which has dripped from the bodies of the sprayed animals.

The spraying solution used is Cooper's New Cattle Dip—an arsenic-containing preparation manufactured by the proprietors as a result of many years' experiment and investigation in South Africa, and elsewhere. A sample of this dip, analysed in the Government Laboratory, Antigua, proved to contain 19·36 per

cent. of arsenic, expressed as arsenious oxide. The directions for use are easy to follow, and the preparation of the spraying solution is accomplished by the addition of the dip to cold water and thoroughly mixing, in the strength required, varying between 1 part in 100 and 1 part in 160. In Antigua it is found that a strength of 1 part in 140 is sufficient. As the surplus drains back through gauze strainers to the tank, and as each animal carries away on its skin something less than ½-gallon of dip, it will be gathered that the cost of spraying per head is very small. Mr. I. E. Dyett, of Ficthes Creek, who has done much of the work of erecting and operating the machine, and to whom I am indebted for much information, tells me that the actual cost per head works out at about ⅛*d*., and it is estimated that the cost of spraying would not exceed 18*d*. per head per annum.

Spraying is repeated in ten days, in the case of animals sprayed for the first time; while those which have been sprayed several times are subjected to a repetition in about three weeks.

Cattle going through for the first time are somewhat refractory, and a possibility of danger to young calves from being trampled on by other animals, occurs. No such case has happened in the present instance, and the danger could be avoided altogether, if necessary, by passing calves through separately. Once the cattle have become accustomed to the machine, there is no difficulty, and the spraying may be performed in very short time. On one occasion seventy-three cattle passed through the machine under notice in seven minutes, each one being effectively and completely sprayed. The animals are found to be dry again in from ten to fifteen minutes, under ordinary weather conditions. It is of course inadvisable, for many reasons, to spray on rainy days.

It is a matter for satisfaction to be able to record that no serious accident has occurred, and only one death can be put down, even indirectly, to the operation of spraying. This was an ox, which, unseen till too late by the men handling the pump, drank a quantity of the mixed solution which was standing ready prepared in a cask near to the tank. A repetition of such accidents is now rendered impossible by the provision of a top to the cask. Two or three slight cases of scalding have occurred from unskilful use of the spray fluid, though happily with no serious result. The worst of these was a young bull, which was inadvertently sprayed three times in five days—twice on the same day. These accidents indicate the nature of the precautions that should be taken when introducing spraying into a district.

Up to the present, no animals except cattle have been sprayed, but there does not appear to be any reason why the operation should not be extended to horses and mules.

The results obtained from spraying have fully justified the most sanguine expectations. It should first and foremost be recorded, that on sprayed cattle it has resulted in a complete absence of ticks. Mr. Dyett states that no ticks whatever have been seen on the animals since their second or third spraying.

It may also be observed, as a result of spraying, that the animals look more thrifty; they are seldom hide-bound—a con-

dition which was formerly common—and their skins are softer and more pliable, while the coat is also improved.

It has not been possible. however, up to the present, to form any opinion as to whether or not the stock work better since spraying operations began. nor has it been found that there is any difference in the amount of food consumed: but the better condition of the stock is very apparent.

It is now a matter of common acceptance that the method by which ticks are killed is by the ingestion of the poison (arsenic) from the skin of the animals, in which the arsenic is present for some time after dipping. Thus it will be seen that the dip will be protective for some little time after its application. The benefit to be derived from such a condition. if pastures were also freed of ticks by fencing and resting, would be inestimable.

The success which has attended this innovation should be sufficient encouragement to those owners who have the interests and the economy of their stock at heart, to follow the lead of Messrs. Henckell DuBuisson & Co. In this connexion it gives much pleasure to state that Colonel the Hon. R. S. Stapleton Cotton is causing to be erected on his estates in Antigua, a similar spraying machine to the one already in operation at Tomlinsons.

The erection of spraying machines is a matter which is well worthy of the attention of stock owners generally, and the writer very strongly advocates their erection in different parts of the several islands of the West Indies. It may be possible in many instances for groups of owners to combine to secure this end.

Fencing, with a view to resting, and the draining and general improvement of pastures should, where possible, be undertaken simultaneously with spraying, and these with improvement in the water-supply in those places where it is needed, would go a long way to mitigate the present waste of live stock and lack of real economy, which unfortunately obtain.

The cost of the machine (manufactured by Messrs. Cooper and Nephews, Berkhampstead, England.) and accessories is £35, while freight and charges bring the same to approximately £40. The cost of erecting. including the pen, was as follows:—

	£	s.	d.	£	s.	d.
Pitch pine scantling ...	17	0	11			
White pine boards ...	3	13	6			
Coal tar		12	0			
Bolts	2	10	0			
Cement	1	19	0			
	1	10	0			
				27	5	5
Cost of machine (approx.)				40	0	0
				£67	5	5

Allowing for local differences in cost of labour and materials. the total expenditure should not in any case exceed £70.

NEW COTTONS: THOUGHTS ON THEIR DEVELOPMENT, PARTICULARLY IN EGYPT,

WHERE ONLY GOOD COTTONS AND COTTON FOR THE FINER COUNTS OF YARN ARE GROWN.

BY JOHN W. McCONNEL,

Vice-Chairman, Fine Cotton Spinners' and Doublers' Association, Ltd.

[The following article by Mr. John W. McConnel, which is reproduced from *The Textile Mercury* (Manchester), of March 21. 1914, is calculated to prove of interest and service to readers connected with the cotton industry in the West Indies. Expressions of views on the part of spinners and users of fine cotton are of very great value to growers, for they are thereby enabled to understand more clearly the requirements of those for whose uses they are growing their commodity.

A real danger exists from the liability on the part of the growers to create false standards of cotton due to their imperfectly understanding the real needs of the spinners. Difficulties, too, arise at times from misunderstanding of the terms used in the grading of cotton: frequently these terms are not self-explanatory; for example, as shown by Mr. McConnel, strength and fineness may include other factors than actual strength and small diameter of fibre.—Ed. *W.I.B.*]

When visiting Egypt—as also on a former visit to the West Indies—I found prevalent in the minds of those concerned with the improvement of cotton some perplexity as to the characteristics which should be aimed at. In the past, the actual practice has been for spinners to buy such cottons as their senses of sight and touch, strengthened and corrected by actual experiments in the mill, told them to be suitable for their purposes. Cotton-growers, on the other hand, have grown such cottons as the experience of years has shewn to be suitable to their lands and climate, and to command a remunerative price. Modifications have been for the most part very gradual. Probably in most cases there has been progressive deterioration of each particular kind of cotton, corrected by the occasional substitution of some new or partially new variety, which has been more or less accidentally developed and has proved attractive to spinners.

Now that the work done by Mr. W. Laurence Balls in Egypt, and (I believe) by Mr. Leake in India, has shewn it to be possible to preserve in a state of purity any particular strain of cotton, and now that it is also becoming possible to modify by hybridization, at least to some extent, such characteristics as fineness, length, strength, productiveness, etc, the whole matter is brought on to a different footing, and it becomes really necessary to consider what are the characteristics to be aimed at by cotton-growers.

In the first place, these characteristics are of two classes: (A) those that interest the grower: and (B) those that concern the spinner :--

Characteristics that Interest the Grower.

(A) The grower is interested to get the largest possible money return. That is to say the two factors of production and price must be such as to give the largest product. (The factor of price may be considered later, as it is affected by questions which concern the spinner.) But for the sake of giving the grower a large production, the scientific breeder has to consider such matters as—Plant habit: such plants as will give the largest number of bolls per acre, and the biggest bolls. Early maturity to escape the attacks of insects Antipathy to insect attacks and fungoid diseases. Health of plant, so as to avoid shedding of bolls, and to achieve ripening of as large a proportion as possible. Lint percentage, to give a good ginning outturn. And all these characteristics have to be considered in connexion with the particular locality.

Characteristics Required by the Spinner.

(B) The characteristics that the spinner wants in cotton are much more diffiult to define. For one reason, the spinner has not been accustomed to look for causes; all that he has cared for in the past has been the result. Would the cotton spin the counts he wanted? Did it give him the strength and cleanliness desired? Were these results achieved with the waste loss to which he was accustomed? Then again language is not definite enough to express wants. 'Silkiness' and 'closeness' convey no clear idea to a grower. Differences of colour can hardly be described at all in words. Even fineness of staple in spinners' language does not necessarily claim that the fibre would be measureably of small diameter. Strength, again, is to a spinner only important as implying that the yarn will be strong - which may probably be more dependent on other qualities, such as those which cause the fibres to bind together into a uniform thread, than on the intrinsic strength of fibre.

However, if cotton is to be developed in future on scientific lines, some attempt must be made to define the characteristics required by spinners :—

Freedom from Waste.

First.—Waste should be reduced to a minimum. Waste adds to the practical cost of cotton. Cotton which gives a spinner 75 lb. of yarn from 100 lb. of cotton is obviously worth more than cotton which only gives 65 lb. or 70 lb Waste is often impossible to remove in the mill, and makes a dirty and undesirable yarn. Waste, again, is a cause of unevenness in the yarn thread and irregularity in its strength and count.

Waste is partly extraneous dirt and trash, partly due to fibres which are shorter when grown than the rest, and still more to fibres which are not properly developed and which break up in

all the processes of a spinning mill. Therefore in all cotton-breeding the first attention should be given to eliminating all the causes of waste.

Your readers in this country are well aware of the difference between combed and carded yarns. But though the comber and the carding engine are so different in their construction and in their action, they have in common the result of taking away some of the shorter fibres. They also, no doubt, both have the effect of breaking into short pieces such of the fibres as are inherently weak. At any rate, in all cotton-breeding the first attention should be given to eliminating all the causes of waste. So far as I know, more attention has been given to this in the West Indies than elsewhere. But the matter is just as important in cottons intended for general use as it is in fancy kinds of Sea Island.

UNIFORMITY TO TYPE.

Second.—Uniformity to type is probably more important than anything else. When one asks that cotton should be fine, or strong, or long, or close, it is not simply a question of the average being these things. What is really wanted is that every plant in the field, and every boll on each plant, and every fibre on each seed, should be as nearly alike as possible in each characteristic.

STRENGTH.

Third.—The qualities that make for strength in yarn are required. How far actual strength of fibre goes to secure strength in yarn is uncertain. Only a fraction of the intrinsic strength of the constituent fibres is made available, even in the best-managed yarns. Much must also depend on the readiness of the fibres to bind together, which is supposed to be closely related to the convolutions in the fibres. It must also depend on their flexibility, perhaps also on their length.

FINENESS.

Fourth.—The qualities which enable fine yarns to be spun. Presumably fineness of fibre must be one of these, and perhaps also length of fibre. Certainly in this, as in regard to strength, *uniformity*, i.e., that every fibre should be as nearly as possible equal to the others in fineness and in length, must be of great importance. This is obvious when the construction of a cotton yarn is remembered.

COLOUR.

Fifth.—Colour is important. This characteristic is, however, almost entirely a matter of fashion or custom. There are a few purposes for which cotton yarns are used in which the clear white of 'Abassi' or American 'Upland' is required; there are also some articles sold in which the brown Egyptian gives the colour or shade required in the garment. But for the most part colour is chiefly important as an index to quality. The buyer of

cotton yarns is suspicious of the quality if the colour is changed; but when once he is satisfied that the quality is right, a new shade, whether lighter or darker, generally becomes as acceptable as was the old. Here again, however, uniformity is essential. (I pass over qualities of minor importance such as elasticity, silkiness, and others.)

In stating here the things a spinner wants in cotton, I am making (as will be seen) no attempt to define what characteristics in the cotton fibre give the desired result. This is work for the laboratory, and should, I think, be available for both grower and spinner. I do not myself know much of laboratory research work in regard to cotton fibre; but there seems room for something more than is commonly known. Mr. Scott Taggart, in his book on 'Cotton Spinning,' shews that observers differ so widely in regard to both length and diameter that the figures are of little use. A little book on 'The Cotton Plant', by Mr. Flatters, of the Manchester School of Technology, gives ome very interesting results of microscopical observation of fibre growth and structure. This seems just the kind of work that is wanted, and more of it will certainly have to be done if cotton-growing is to become in any sense an exact science. My own object at the moment is to try and express in language that can be understood by those on whom scientific cotton-growing depends, what the qualities are that spinners want to find increasingly in the cottons of the future.

Are Good Qualities Mendelian?

Now it seems to me that one very important question has to be faced at the very beginning of this modern science of improving cotton on Mendelian lines. This question is—Are all these desirable qualities attributable to Mendelian characteristics? We have seen that for the sake of the grower, plants must be capable of producing the largest possible quantity of lint per acre. Are the characteristics that lead to this result capable of development on Mendelian lines? That is to say, can plants be hybridized so as to develop bolls instead of wood, lint rather than seed, so as to be early maturing, healthy, antipathetic to insects and fungi?

We have seen also that the spinner requires freedom from waste, fibres that will make a strong yarn, fibres that will spin to the fineness required in each branch of the trade, in some cases special colour, and above all and in every characteristic the spinner desires uniformity. Can the Mendelian breeder give us these things? In the practice of the best cotton growers of the past, so far as I know, dependence for the improvement of all these qualities has been placed first on the soil and climate, and second on selection. I presume the Mendelian scientist recognizes soil and climate as still governing factors in the problem. Is it admitted still that plants of a good plant habit will generally produce the same? That the seeds of plants producing $1\frac{1}{4}$ inch staple in a field where the average is $1\frac{1}{8}$ inch, will next season give longer cotton than the rest? That the tendency of plants to make waste by irregular or badly developed fibres can be resisted by persevering selection of those plants in the field that are best in this respect? Can fineness and can strength be improved by selection?

This is the great question at the moment. Mr. Balls is, I understand, generally admitted to have established the fact that any particular cotton can be grown pure and kept pure on a sufficiently large scale to give cotton pure enough for practical purposes through the greater part of Egypt. The great question is—How far can he and his successors govern the qualities of the cottons which they will grow in future years? Are all the good qualities to be got by patient experiments in hybridization, or can some of them—and if so, which—be obtained by plant selection?

PRICES.

A few words may be added on the matter of prices. In conferences between spinners and growers there are generally appeals and recriminations exchanged in regard to prices. The actual fact, however, is that neither spinner nor grower can really fix prices at all. The planter will plant the kind of cotton which will give him the best return in money. The first point with him is, therefore, production, and in Egypt the usual system of buying the crop seems to lead to special importance being attached to the proportion of lint to seed. On the other hand, the spinner is always trying to buy the cotton that suits him best. In regard to the qualities which I have said he is looking for, the spinner will always pay more for cotton that is free from waste than for cotton that is wasty. Again, he will always pay more for regular cotton than for irregular. Uniformity and freedom from waste will always command more money. Strength also—at least the qualities in cotton that make yarn strong—will generally command a higher price. But there is a limit here: strength of yarn beyond the ordinary usage of the trade would be of little immediate value. Fineness again (i.e., the qualities which enable fine yarns to be spun) is even more limited as an element of value. So far as the world requires very fine yarns, cottons to spin them command very high prices; and so with each degree of lessened fineness. There is a very real but very small trade in very fine numbers; there is a larger trade in the next range of counts; a trade again larger as the counts go coarser; and (to make these remarks practical) we may assume that the next range coarser is that in which Sakellarides cotton was first used. That trade is also limited, though larger than that in the ranges finer still.

Now the practical point here is that—since the production o Sakellarides has been increased beyond the world's requirements in the moderately fine range of yarns for which it is suitable—the price of Sakel has fallen down to or below the price of some other kinds of Egyptian cotton. This well illustrates what must happen always in regard to this matter of fineness, or, in a less degree, in the matter of strength. On the one hand, if more be produced than the world can take off in yarn, the price will necessarily fall. On the other hand, if the cotton is cheap to produce (as I understand is the case with Sakel) the grower will continue to grow it even though it no longer commands a premium over the prices of cottons that used to sell for less money. It is (as I said before) the return to the grower that will guide him in what he grows. Doubtless before long the finer or stronger fibre will shew its merits even in the coarser yarns, and will create for

itself a larger demand, and some consequent regain of premium. In the meantime, however, the grower must and will be satisfied by the great productivity of this cotton. Prices are always tending to adjust themselves in inverse proportion to productivity.

THE SCIENTIFIC BREEDER AND PRICE.

The question arises whether there is any room here for action by the scientific breeder. As to this, it is obvious in the first place that the principle just stated gives him another rule in regard to his new species. It is no use his developing cottons unsuitable for fine yarns or unsuitable for extra strong yarns, unless he can secure in place of the qualities which give fineness or strength so large a measure of extra productivity as to give the same gross value at a lower price per pound. (For the sake of brevity I write as if all lands in Egypt were alike, but of course I am aware that in different districts different cottons seem to specialize. But the general argument will apply alike to all districts.)

In the second place, it seems to me obvious that in a country such as Egypt, where the State is aiming at being the fountain of good seed, it must be desirable for the Department of Agriculture to study carefully and continuously the requirements of the trade. This cannot be readily done by making categorical inquiries from spinners. Spinners are partly unable and partly unwilling to fill up detailed returns as to their past and future consumption of special cottons. The actual off-take of different kinds of cottons can be learnt from merchants; but what I believe spinners could do, and would be willing to do, would be to explain why particular cottons were gaining or losing hold on the market. Personal interviews between a properly qualified Government official and a few individual spinners would shew the Department in what directions their efforts should be turned.

I must guard myself, before I close, from being understood to advocate the breeding of new strains of cotton, different from those in common use. Just as uniformity of staple is valuable, so is continuity in quality. But as apparently all cottons deteriorate unless the breed is kept pure, it becomes the business of a seed farm, whether public or private, to provide pure seed. And in selecting from the cottons usually grown the particular strains which he intends to keep pure, the cotton breeder has necessarily to know what qualities are required.

I have written all this more as an inquirer than a teacher; and I hope both scientific students in this country, and those who are engaged in scientific work in connexion with cotton-growing, will contribute to the discussion of this important subject.

NOTES ON SOME PARASITES OF LIVE STOCK IN THE WEST INDIES.

BY P. T. SAUNDERS, M.R.C.V.S.,

Veterinary Officer on the Staff of the Imperial Department of Agriculture.

During the summer months of 1913, it fell to the duty of the writer to collect parasites, both internal and external, of live stock in some of the West Indian islands. Collections were made in Antigua, Montserrat, St. Kitts and St. Vincent.

Through the kindness of Mr. G. A. K. Marshall, Director of the Imperial Bureau of Entomology, these have been identified and the accompanying list has been received. The present notes include inferences and deductions from that list, together with notes made on the spot by the writer.

The identifications of the ticks and the flies were made by Prof. G. H. F. Nuttall, F.R.S., and Mr. C. Warburton, the entozoa by Mr. H. A. Baylis, and of the fleas by the Hon. N. Charle Rothschild.

ENTOZOA.

(Determinations by Mr. H. A. Baylis.)

ACANTHOCEPHALA.

Echinorhynchus gigas, Goeze—from pig, St. Vincent.
E. moniliformis, Bremser—from rat, St. Vincent.

NEMATODA.

Oesophagostomum inflatum, Sch.—from calf, St. Lucia.
O. venulosum, Rud.—from sheep, Dominica.
O. columbianum, Curtice—from sheep, St. Vincent.
O. dentatum, Rud.—from pig, St. Vincent.
Filaria cervina, Duj.—from bull, Antigua.
F. papillosa, Rud.—from horse, Mustique.
Oxyuris curvula, Rud.—from pony, St. Vincent.
Stephanurus dentatus, Dies.—from pig, St. Vincent.
Sclerostoma equinum, Duj.—from pony, Mustique; horse, St. Vincent.
Strongylus micrurus, Mehlis—from ox (lung), St. Vincent.
S. paradoxus, Mehlis,—from pig (lung), St. Vincent.
Heterakis inflexa, Rud.—from fowls, St. Vincent.
H. spumosa, Schneider—from rat, St. Vincent.
Spiroptera obtusa, Rud.—from rats, St. Vincent.
Ascaris megalocephala, Cloq.—from horse, Mustique.

CESTODA.

Moniezia expansa, Rud.—from sheep, St. Kitts.

Davainea tetragona, Molin—(*Taenia bothrioplitis*, Piana)—from fowl, St. Vincent. (Specimens not well enough preserved to be determined with absolute certainty.)
Taenia crassicollis, Rud. (larva) (*Cysticercus fasciolaris*, Rud.)—from rat (cysts in liver), St. Vincent.

ECTOZOA.

ACARINA.

(Determined by Prof. G. H. F. Nuttall, F.R.S., and Mr. C. Warburton).

(Argasidae.)

Argas persicus, Wald.—off fowls, Antigua.
Argas sp.—larvae, off rat (*Mus Norvegicus*), St. Vincent.

(Ixodidae.)

Amblyomma variegatum, F.—off cattle, Antigua.
Boophilus australis, Fuller.—off cattle, Antigua,
off ox, at slaughter-house, Antigua.
off cattle, Montserrat;
off cattle, St. Kitts;
off cattle, Nevis;
off cattle, St. Vincent;
Dermacenentor nitens, Neum.—off horse St. Kitts, Montserrat (also off donkey) and St. Vincent.
Rhipicephalus sanguineus, Latr.—off dogs, Antigua, Montserrat, St. Kitts, St. Vincent.

PULICIDAE.

(Determinations by the Hon. N. Charles Rothschild.)

Ctenocephalus felis, Bouché—off fox terrier, St. Johns, Antigua; Plymouth, Montserrat; cat, St. Kitts; and rats, St. Vincent.
Xenopsylla cheopis, Roths.—rats, St. Vincent.

DIPTERA.

Sarcophaga otiosa, Will.—St. Vincent.
S. plinthopyga, Wied.—St. Vincent.
S. aurifinis, Walk.—St. Kitts.
Sarcophaga sp. (not in the British Museum)—St. Kitts.
Chrysomyia macellaria, F. (Screw worm fly)—Antigua St. Vincent.
Lucilia sp. (not in British Museum)—St. Vincent.
Musca domestica, L.—St. Kitts, Antigua, St. Vincent.
Coenosia sp. (not in British Museum)—St. Kitts.

Dealing first with the external parasites, it is obvious that ticks constitute the most important pest of live stock in these islands. Specimens were obtained from cattle, horses, donkeys, and dogs in the islands mentioned, and it is a significant fact that in each case the identifications agree in the several islands with respect to the ticks on each of these host animals.

The common or 'creole' cattle tick was obtained from Antigua, Montserrat, St. Kitts, Nevis and St. Vincent, and proved to be *Boophilus* [Margaropus] *australis*, Fuller. The specimens were obtained in different circumstances: some from working oxen, some from the animals in the slaughter-house, and some from animals at pasture. It seems, therefore, reasonable to suppose that the common cattle tick in other islands in the West Indies is the same species, although definite records

are wanting. It is well, of course, to remember that other ticks may be found at times on cattle, but the evidence appears fairly conclusive that *B. australis* is the one commonly referred to as the cattle tick.

Boophilus australis, Fuller, is a variety of *Boophilus bovis*, Riley (*Rhipicephalus annulatus*, Say), which is well known as the carrier of Texas fever. This tick, or one of its several varieties, is widely distributed in Africa, North and South America, Oceania, Asia and Europe. It has two moults on the host, from the larva to the nymph and the nymph to the adult, and the entire life-cycle may be completed in two summer months, but is seldom completed in less than two and a half or three. (Lounsbury). It is probable that at least two if not three or more broods occur annually in the suitable climate of the West Indies.

In none of the islands, with the exception of Antigua, is any attempt made to deal with ticks in a satisfactory manner. The method of pulling off the ticks by hand, and smearing the parts with a weak solution of Jeyes fluid is all that obtains. In Antigua, however, it is gratifying to record that a spraying machine for cattle has been erected on the estates controlled by Messrs. Henckell Du Buisson & Co., which is doing excellent service. For a description of this machino the reader is referred to the article in the present number of this Bulletin. (See p. 123).

Another cattle tick which is a serious pest in Antigua is *Amblyomma variegatum*, Fabr. Its common local name is the 'gold' tick, so called from the yellowish-red markings on the scutum of the male, which give the tick a handsome golden appearance. It is alternatively known as the 'St. Kitts' tick. The latter name is derived from the neighbouring island of St. Kitts, where the tick is supposed to have been originally introduced. No such tick has however been seen in St. Kitts by the writer, though special search has been made for it, and it appears to be quite unknown there. It is much more probable that the tick was brought to Antigua with an importation of Senegal cattle many years ago. Of the British islands, it is only known in Antigua, but it is also recorded from Guadaloupe (*Neumann's Parasites and Parasitic Diseases of the Domesticated Animals*, p. 98). It is originally an African tick, and Neumann speaks of it as the principal one of the African genus Amblyomma. In size, it is one of the largest ticks known, the female reaching dimensions as large as a damson. One engorged female coming under the writers' notice weighed 3·51 grammes. The mouth parts are very strong and are capable of firm fixation in the skin; cattle being ticked, while remaining quiet during manipulation of the creole tick, bellow in pain when a gold tick is being pulled off. Usually, there comes away with the mouth parts small pieces of skin, so firmly does the tick attach itself. In consequence of this, it is the practice on some estates to cut off the gold ticks, but the mouth parts left in the skin almost invariably produce a festering wound. In Africa, they are supposed to attack the ox, sheep, horse and man, but in Antigua they appear to attack cattle only, and the writer has no knowledge

of their occurrence on other animals. The incidence of this tick is seasonal: they appear in small numbers about July, and in very dry seasons even a little earlier, but they are present in large numbers in the autumn months. They attach themselves to almost any part, but the selected sites are on the under surface of the body, particularly the dewlap and escutcheon.

Their economic importance depends on the fact that they are supposed to be concerned with the transmission of skin disease in Antigua, either by direct means, or by providing the necessary wound for infection from other sources.

The tick attacking horses in St. Kitts, Montserrat and St. Vincent, and donkeys in Montserrat, is *Dermacentor nitens*, Neum. Both male and female forms together with the larvae are commonly found in the external ears of horses. There are no signs of discomfort apart from what may be expected from irritation and some loss of blood. The host does not appear to make any attempt to get rid of the parasites by rubbing the head and ears against posts or other objects. As far as is known, they are not concerned with the production or transmission of disease.

The common dog tick of these islands is *Rhipicephalus sanguineus*, Latr.

Specimens were obtained in Antigua, Montserrat, St. Kitts and St. Vincent. Some were taken from dogs which were ostensibly housedogs, while others were obtained from dogs of mongrel breed, which ranged the streets in search of food. The commoner sites of the ticks were in the ears, and in between the digits, though they were found on almost all parts of the body. No case came to the writer's knowledge of any harmful effect produced by them except for the constant irritation and rubbing which always accompany their presence.

The fowl tick, *Argas persicus*, Wald., has been met with in several islands. Specimens were obtained in Antigua and despatched to England for identification. It was then found that the specimens were the Persian tick (known also in Persia as the Miana bug, where it is a scourge of man) and not the *Argas miniatus*, which is found in America, particularly in the Southern States. In the West Indian islands they are a common pests of fowls, and in many instances, they render the rearing of chickens almost impossible. They are active at night, attaching themselves to the young chickens, but are not to be seen in the day time in the fowl-house, where they lie hidden in the woodwork. It is no uncommon experience for owners to encounter such difficulty in destroying these ticks by means of spraying, etc., that the better plan appears to be that of burning the fowl-house, and keeping fowls away from the premises for some time. These ticks may also attack other animals, including man.

The opportunity was taken of collecting several specimens of fleas in some of the islands. The common flea of dogs and cats in St. Kitts, Montserrat and Antigua proved to be *Ctenocephalus felis*, Bouché. They were very numerous in all cases. Many fleas were also collected in St. Vincent from rats

which were being trapped and slaughtered during the recent campaign against this vermin. By far the great majority of these were *Xenopsylla cheopis*, Roths., while a few of the *Ctenocephalus felis* were also found.

Many diptera or true flies were also collected, and a point of interest occurs in the fact that the *Chrysomyia macellaria*, F., so well known as the screw worm fly in St. Lucia has been obtained from Antigua and St. Vincent. At the time of writing, the identifications of the diptera were not completed, but there does not appear to be any reason why this fly should not be located in all the several islands; and indeed, it is the opinion of the writer that this is so. Two species of flesh flies, *Sarcophaga otiosa*, Will., St. Vincent, and *Sarcophaga auristifin*, Walk, St Kitts, were collected, of which further specimens are desired for the British Museum collection, which points to their comparative scarcity. Another feature of interest is that three new species have been discovered in the collection submitted. These include a species of the genus Sarcophaga, one of Coenesia from St. Kitts, and one of Lucilia from St. Vincent.

Turning to the entozoa or internal parasites, most prominence perhaps should be given to the Oesophagostomata, small hook-worms closely related, and almost analogous to, the anchylostoma of the human being. A note has already been published on these parasites in the *AgriculturalNews*, Vol. XII, No. 288, p. 149. They appear to be of sufficient interest and importance to form the subject of a further article, and it is not therefore intended to deal at length with them on this occasion. Specimens have been obtained in different islands from various animals, and the list enumerated should serve as a guide to their prevalence. *Oesophagostomum inflatum*, Sch., was obtained from a calf in St. Lucia. *Oes. columbianum*, Curtice, was found in sheep in St. Vincent, and *Oes. dentatum*, Rud., is common in pigs in the same island. *Oes. venulosum*, Rud., is found in sheep in Dominica. The *Oes. columbianum* is the cause of the nodular disease of the intestines of sheep, which is also to be seen in the islands. Specimens not yet identified, but presumed to be *Oes. inflatum*, Sch., have been obtained from cattle in Antigua. It is further the opinion of the writer that these parasites will be found to exist in all the islands.

Another group of parasites which cause much mischief are the hoose worms, those strongyli of the air passage which give rise to the condition known as verminous bronchitis. The more common of these are *Strongylus micrurus*, Mehlis., of the ox, and *St. paradoxus*, Mehlis., of the pig. It occasionally happens that an animal is at one time the subject of infestation by a strongylus and one of the oesophagostomes, previously mentioned, and the cachexia produced is severe enough to be fatal. Many such cases have come to the notice of the writer, particularly in a season of drought when the food supplied is not adequate to meet the increased bodily requirements due to parasitism. Deaths may occur from the presence of the

A case of severe tick infestation of a horse at Barbuda is reported to have resulted in a form of paralysis followed by death of the horse. The tick has not been identified but is likely to prove to be *Dermacentor nitens*, the cattle tick being stated not to occur in that island.—Ed. *W.I.B.*

strongyli alone, especially in cattle, while pigs appear to harbour the parasites without much effect upon their health, though their lack of condition is partly attributable to their presence. It is the common experience of St. Vincent, for instance, to find that 50 per cent. of the pigs slaughtered at the abattoir are hosts of this Strongylus.

None of the internal parasites of horses appear to cause much definite disease. *Ascaris megalocephala*, Cloq., is often found in the intestines of horses on post-mortem examination, and occasionally in life may cause colic on other digestive derangement.

The *Sclerostoma equinum*, Duj., is also found in some few cases. The writer has not, however, met any case of disease which could be ascribed to their presence, though it is not improbable that many cases in which young horses lose condition and eventually die, are due to the effects of this worm or its larval form. The habitat of the adult is in the small intestine, but the larval worm lives in the anterior mesenteric artery, and may produce colic or peritonitis. In England this parasite causes a good deal of loss in horses, particularly young horses in the fields, but it does not appear, fortunately, to be very common in the West Indies.

The *Oxyuris curvula*, Rud., a worm of whip-like appearance, is commonly seen in the fæces of horses, and, in common with experience of it in other parts of the world, has no markedly harmful effects.

The *Filaria papillosa*, Rud., of which specimens were obtained in St. Vincent, is not commonly found as a parasite of horses, and when present, does not appear to do much harm. Its habitat is in the serous cavity of the abdomen, and it is more likely to be found if the host is cachectic.

A similar parasite, *Filaria cervina*, Duj., has been seen inhabiting the abdominal cavity of cattle.

In sheep, a tapeworm, *Moniezia* [taenia] *expansa*, Rud., is sometimes to be met with in large numbers. One sheep slaughtered for food in the abattoir of St. Kitts was found to contain more than twenty specimens in its intestine, many of them being 6 feet or so in length.

Pigs appear to be more susceptible to parasites than other animals. In addition to the oesophogostome and strongyle already mentioned, the pig is the unfortunate host of many other parasites. The *Echinorhynchus gigas*, Goeze, is sometimes found in the small intestine of pigs slaughtered for food in the abattoir in St. Vincent, and *Stephanurus dentatus*, Dies., is not an uncommon slaughter-house specimen in the same island. This latter worm lives in the fat surrounding the kidneys, and is also, on occasions, to be found in the bile-ducts of the liver. Here they are encysted, and the sac of the cyst is only large enough to contain one parasite, or rarely two, and a small quantity of a dark glutinous pus. Their presence in the kidney fat appears to exert no deleterious effect on the condition of the animal; the carcass is passed for food after the affected kidneys and the surrounding parts have been removed.

Amongst fowls, *Heterakis inflexa*, Rud., is apparently the cause of many deaths. A fowl may be found dead and it may then be noticed that others in the same yard are drowsy and lose their feathers, and show other signs of unthriftiness. If not checked medicinally, the loss of fowls will be very large. Specimens were obtained in St. Vincent and St. Kitts.

Davainea tetragona, Molin, (*Taenia bothrioplitis*, Piana.,) was also found, as a parasite of fowls.

Other specimens included in the collection mentioned above were: *Spizoptera obtusa*, Rud., found in the stomachs of rats; *Heterakis spumosa*, Schneider, and *Echinorrhynchus moniliformis*, Bremser, from the intestine of rats; and *Cysticercus fasciolaris*, Rud., a small cyst in the liver of rats, containing the larval form of *Taenia crassicollis*, Rud., which is known as a tapeworm of the cat.

MAL DE CADERAS.

BY P. T. SAUNDERS, M.R.C.V.S.,

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Imperial Department of Agriculture.

The present article has been written in view of the recent outbreak of Mal de Caderas in British Guiana, where the disease has been the cause of much anxiety, both to owners of stock, and to the Government.

Much of the information contained herein has been obtained from a communication from the Technical Section—Direction of Veterinary Services, Rio de Janeiro, Brazil, and transmitted through the British Consul-General. The communication is over the signatures of Alcides Miranda and T. W. Cananea, and is approved by Josè Luiz Monteiro de Gouvea, the Director of Section. Acknowledgement is also made of an article by Capt. A. L. Farrant, F.R.C.V.S., of British Guiana, in the *Veterinary Record* of March 28, 1914, for many useful points.

Mal de Caderas (or Cadeiras) is an epizootic disease of equidae in South America caused by the *Trypanosoma equinum*. It is known under several names in different countries. In Brazil it is known as peste de caderas, in Paraguay and the Argentine as tumby-baba or tumby-a, flagellosis of equidae, trypanosomiasis of equidae, quebra bunda (or break-loins), disease of the rump and disease of the haunches.

It is widely spread in South America, and there is knowledge of its existence in Brazil, the northern parts of Argentine Republic Paraguay, Uraguay, Chile, Bolivia, British and Dutch Guiana, while it probably also exists in Peru and Venezuela. In the Argentine it occurs in the provinces of Formosa, Chaco, Missiones, Salta, Santa Fé, Santiago del Estero, and parts of

Tucuman and Catamarca. In Brazil, it occurs mostly along the great rivers (though not all) in the island of Marajo, at the estuary of the Amazon, along the lower reaches of the river Purus, especially in Acre, along the river Paraguay and its affluents, the river Sao Francisco, in Bahia, Minas Geraes and Matto Grosso.

It has not been definitely recognized in the islands coms prising the Lesser Antilles, but cases of disease, more or les- resembling mal de caderas have been observed.

Though essentially a disease of horses, it also affects in less degree mules and asses, the former taking an intermediate position in order of susceptibility, but the effects are not so rapid nor is death so soon produced in these animals. Lignières gives the order of susceptibility experimentally, as follows: white mouse, black rat, grey mouse, grey rat, dog, horse, mule, monkey, rabbit, cat, guinea pig, sheep, goat, ox and pig.

The disease appears to have been first described clinically by Rebourgeon in 1889, and again by Leclerc in 1899, but the first to establish definitely its etiology was Elmassian in 1901 in Paraguay. Later in the same year the causal agent was described with much precision by Voges of Buenos Aires. It has since been studied by Lignières, and also by Lutz.

As already stated, the causal organism is *Trypanosoma equinum*, which in appearance closely resembles the causal agents of nagana and surra, from which, however, it differs by the difficulty in seeing the centrosome or blepharoplast, which last forms its principal characteristic. According to Martin Meyers, that author has observed a specimen of the trypanosome from Brazil in which the centrosome stained a brilliant vermilion colour, a fact which is difficult of observation in the case of specimens from the Argentine Republic and Paraguay. In size it is variously stated to be 20 to 26 microns in length and 2 to 4 microns in breadth. Its vitality, comparatively, is not very great: in fresh blood taken at the outset of disease the trypanosome may live two or three days, but the addition of one part distilled water to two parts of blood is sufficient to kill it in an hour. It is very sensitive to heat, 42° C. being sufficient to kill it in forty-five minutes. It resists cold well, and is not killed by freezing for two or three days. It is killed by antiseptics in the following order: carbolic acid, creolin, lysol, permanganate of potash, bichloride of mercury, boric acid.

Good preparations for microscopical examination can be made by spreading a thin film of blood on a slide (by the Janeso-Rosembruger process). This is allowed to dry, is then fixed in absolute alcohol and stained with Giesma, Leishman or with May-Grunwald.

It is stated that for purposes of diagnosis, it is almost always easier to inoculate 5 to 10 c.c. of the blood of a suspected animal into house or ordinary rats, rabbits, dogs or guinea pigs. At the end of a certain period of time, usually eight to fifteen days, the parasites appear in the peripheral circulation, and a fresh cover-glass preparation reveals the living trypanosomes traversing the microscopic field with some degree of

rapidity. In Brazil, diagnosis by this means has been made through the medium of the guinea pig in fifteen days, in spite of the assertion of some authors to the effect that the incubation period of *Trypanosoma equinum* in guinea pigs is very long. In this connexion, it should be mentioned that Laveran and Mesnil have observed an incubatory period of 120 days.

An important step in the elucidation of the mode of natural transmission was achieved by the verification of the existence of an animal which serves as as a natural reservoir of infection, The researches made in Brazil, in Paraguay and the Argentine Chaco leave no doubt that the capivara (*Hydrochoerus capibara*) a species of water-hog, acts in that capacity. In Spanish-speaking countries this animal is known by the name of carpincho. The circumstance of finding these animals to be the natural reservoir of the infection explains at the same time the geographical distribution of the disease, the capivaris living in the pools along the margins of rivers; while it is known that the chief foci of infection follow the course of rivers.

The capivaris in addition to being hosts of the trypanosome in the latent condition, frequently themselves become victims of that parasite. It often happens that an epizootic of mal de caderas in horses is preceded by great mortality amongst capivaris, and large numbers of them may be found dead along the river banks. The finding of numbers of dead capivaris is locally taken as a sure sign of an approaching outbreak of mal de caderas amongst horses. It should be remembered too, that cattle and other animals may possibly act as reservoirs without showing symptoms themselves, though no definite proof of this is forthcoming.

Although the reservoir of the virus is already known, the exact means of transmission from capivaris to horses is not yet definitely established, and careful study in this connexion is at present being pursued in Brazil. It was once thought that the trypanosome was carried from one animal to another through the bite of leeches, but this theory is now given up for the more probable one of transmission by biting flies. It may also be possible that the disease is conveyed mechanically from a wound or raw surface to another such, on a non-infected animal, but in the great majority of cases, there appears to be little room for doubt that the mode of transmission is biological through the medium of biting flies. In British Guiana, it is held that the common biting stable fly (*Stomoxys calcitrans*) is the means of propagation. In Brazil, however, the most authoritative conclusions drawn in that connexion by Lutz and Neiva tend to show that transmission is effected through the intermediary of 'Tabanideos' (Tabanidae), which are well known in Brazil under the name 'mutucas'. In early work on the disease by Sivori, Leclerc and Voges, the opinion was expressed that the insect concerned was the Moscus Bravas, a wild fly, but they were unable to decide definitely the exact species. Several species of chrysops, however, to which family the tabanidae belong, are known to exist in Brazil, and may be observed in great abundance biting the heads and ears of horses.

The symptoms of the disease are vague and indefinite at first, but later are quite characteristic. Lachrymation is early evident, the tears either clotting at the corner of the eye, or later running profusely down the face. A gradual loss of condition may be observed, accompanied by a progressive anaemia and rapidly increasing weakness. The appetite is fickle and fails to some extent at this stage, but later it improves and is maintained to the end. Petechiae or ecchymoses of the mucous membranes are to be observed, especially on the membrana nictitans, one or many, which as the disease progresses, may coalesce. This is very characteristic of the early stages. Fever occurs, which in some cases may be as high as 107°F. at first remittent and later intermittent. The trypanosomes can usually be found in the blood during the height of the fever. In the later stages the temperature returns to normal (100 to 101° F.), while still later in the chronic stages, it may be sub-normal (98 to 99° F.). Albuminuria and haematuria are noticed in some cases, but not in all. In British Guiana it has been observed that haematuria occurs more in females than males. The trypanosome has never been found in the urine, however, in any case. Conjunctivitis and chemosis are sometimes present. The penis of the male may be projected from the sheath with slight erection for 6 or 8 inches, and may be bent to either one side or the other, and the condition persists when once established. An eruption of a moist nature may occur on the neck, shoulders and hindquarters. It occurs in patches of about 1 to 1½ inches in size, covered with a scab, and the part is denuded of hair. The most characteristic symptom, however is the gradually increasing paraplegia, a paralysis of the hindquarters, associated with a dragging and a characteristic crossing of the legs. The hindquarters droop and sway from side to side. As the disease progresses, the animal leans against a tree or fence, draws his legs under him and sleeps. Later the animal falls and may rise, but later falls again and is unable to rise. The paralysis progresses, the anus is open, the rectum packed with faeces, and the animal dies comatose.

The duration of the disease varies somewhat in different animals. In horses, death usually takes place in from two to five months, though in acute cases death may occur in three or four weeks. In mules and asses, however, the disease lasts longer—six months or more—and in some cases death does not occur for twelve months.

Diagnosis depends on the finding of the trypanosome in the blood of affected animals, or an inoculation of blood into a laboratory animal, followed by subsequent demonstration of the parasite. It can be differentiated from other trypanosome infections, e.g., surra, by the difficulty of staining the centrosome. Clinically, the existence of petechiae of the mucous membranes and later, the characteristic paralysis of the hindquarters are important.

The disease is almost always fatal to horses, and any animal which apparently recovers is useless for working purposes for some considerable time, on account of the weakness of the hindquarters. In some districts of the Argentine,

it is stated that it decimates the herds of horses, which require to be replenished every year. In many parts of South America, cattle are used for riding and driving purposes on account of this disease.

The post-mortem appearances of the disease are vague and indefinite, and practically no abnormal condition other than congestion is met. The carcase is emaciated, the muscles pale and atrophied, and the muscles of the hind-quarters may have haemorrhages in them. Petechiae may be present on the endocardium and perhaps on the spleen or other organs, and a straw-coloured fluid may be found in the serous cavities. The lungs are pale, with centres of congestion ; the liver is enlarged, soft and pale, and the spleen may be enlarged.

The treatment of the disease has up to the present yielded no definite satisfactory results. Lignières tried all the then known remedies without avail. Quinine, methylene blue, salicylic acid, carbolic acid, permanganate of potash and other antiseptics have been administered, and bichloride of mercury has also been tried hypodermically. Arsenious acid and allied preparations have also been used, but the improvement produced was of a temporary nature. Salvarsan proved useless. The continuous administration of potassium iodide and mercury biniodide is said to give useful results at some stages.

In Brazil, experiments have recently been carried out with atoxyl and acresar, and appear clinically to be of some service, but no microscopical examination was made by way of control. The probability appears to be that, like many other remedial agents, the improvement is temporary, and there is a disappearance of the trypanosome from the peripheral circulation without a cure being effected. Recurrence of the disease has been observed in some of these cases. At the present time, efforts are being concentrated on the employment of antimonial salts and hopes of success are held.

The lack of success of treatment renders the prevention of the disease of more importance. Prophylaxis, admittedly difficult, appears to resolve itself into a campaign against the natural reservoir, the capivaris, or against the transmitting agent, the biting flies, combined with destruction of affected animals and adequate disposal of carcases. The extermination of capivaris is not feasible, both on account of the cost and because the success of such an undertaking would be very problematical, by reason of the mode of life of these animals. It has been suggested, however, that the oil yielded by the capivaris being a somewhat valuable commodity, this might be sufficient to enable the authorities to institute a campaign against them. There does not appear to be any reasonable chance of success in finding a practicable solution to the problem through biting flies. The achievement of only partial success in Africa against the carrier of sleeping sickness is sufficient evidence of the difficulty of a campaign of extermination against flies.

There remains, then, the other method of fighting fly-borne infections : that is by protecting the animal against them. This may be accomplished by screening stables, and by a daily dressing of the animals with kerosene emulsion or other mixture obnoxious to flies. It will easily be apparent, however, that much good

cannot be looked for in such a way, and hopes of ultimate success will probably remain in medicinal treatment. It is worthy of note, however, that much attention is at present being paid to the attempt to produce a serum or other immunizing agent, though as yet the efforts of workers in this direction have met with no success.

A NOTE ON THE M'FADYEAN STAINING REACTION FOR ANTHRAX BACILLI.

[The following paper, by Major J. D. E. HOLMES, M.A., D.Sc., M.R.C.V.S., Imperial Bacteriologist, Muktesar Laboratory, India, has been reprinted from Bulletin No. 36, of the Agricultural Research Institute, Pusa. The plates in the original have been omitted here.]

In the Journal of Tropical Veterinary Science, Vol. IV, No. 1, pp. 68-70, Mr. Mitter of the Bengal Veterinary College drew attention to a supposed difference between the staining reactions of anthrax bacilli in that Province of India and in the Continent of Europe. In brief, he was unable to obtain the violet staining reaction which M'Fadyean described as being diagnostic of anthrax bacilli when an anthrax film is treated with a 1 per cent. methylene blue solution. In 1903, in the Journal of Comparative Pathology and Therapeutics, M'Fadyean published a paper in which he fully describes the method of obtaining the violet reaction, and remarks on its value as a diagnostic agent both in fresh and in putrid anthrax blood. There are many points of technique on which the author lays special stress, and which should be carefully noted by every one wishing to obtain similar results.

The reaction is obtainable only in preparations of anthrax from blood and other body fluids, not in artificial cultures of the bacilli. Schäffer of Berlin, while confirming M'Fadyean's observations found that when anthrax was grown on blood serum, on which medium the bacilli form capsules, the red staining of the capsules could be observed. The violet staining is constant in anthrax of any of the domesticated animals as well as in the mouse, guinea pig and rabbit. It is obtainable immediately after death, and it may still be detected when all the anthrax bacilli have undergone dissolution in the unopened carcase. The reaction is diagnostic of anthrax. In a well prepared film of anthrax, the colour reaction is so marked that in most instances it is possible to detect the trace of red or purple by the naked eye inspection, especially when it is held up to the light.

To prepare the film, a smear preparation is made in the ordinary method. The film should not be very thin, for then the fixation is liable to be too complete. For the same reason, the film should be spread on a slide, and not on a cover-glass. After drying at ordinary temperature, the slide is fixed, by lowering it, film side upwards, into the flame of a Bunsen burner,

for a second. Repeat this three times, or until the under surface of the glass is a little too hot to be borne by the skin of the palm of the hand. Particular attention should be paid to the process of fixation, as the violet reaction is obtained when the preparation is *imperfectly fixed.*

M'Fadyean draws special attention to this. 'It is important to notice that what might be thought trivial departures from the directions given above will entirely prevent one from obtaining the reaction. For instance, if the film be fixed with sublimate, formalin or osmic acid solutions, no trace of the violet reaction will be obtained. Failure will also occur if, in fixing the film by dry heat, the temperature is allowed to rise as high as 150°C. 100°C. is sufficient, and it should not be allowed to rise much above that. Again, the film ought not to be very thin. Partly for this reason, and partly because of over-heating in the Bunsen flame, such thin films as are obtained by pressing two cover glasses together, generally fail to show the violet reaction. As an alternative method of fixation, the slides or cover glasses carrying the dried films may be immersed for a few minutes in absolute alcohol or methylated spirit. The stain must not be applied to the hot slide, or heated until the steam begins to rise, as is recommended for some methods of staining, nor must the preparation be washed in alcohol after staining.'

It is also necessary to be careful that the stain is lightly washed off and that no pressure is used when drying the film between absorbent paper. The violet-stained amorphous granules of the capsule, being imperfectly fixed, are easily removed from the film, and rough handling in washing or drying may cause an apparent failure to obtain the reaction. As regards the stain, M'Fadyean was, at first, of opinion that it was necesary to use a 1-per cent. solution of methylene blue which had been in stock for some time and thus acquired a polychromatic quantity, or that it was necessary to add a ½ per cent. bicarbonate of soda to a freshly prepared, 1-per cent. solution of Grubler's powder. Subsequently, it was found that freshly prepared, pure medicinal methylene blue gave the reaction, without the addition of bicarbonate of soda.

For some years past I have made use of the violet reaction in the diagnosis of anthrax, and have never failed to obtain a positive result, in anthrax blood, when the above directions have been carefully adhered to. I have used it in summer and winter temperature, both on the hills and on the plains in India, and found no variation.

I am therefore inclined to believe that Mr. Mitter's failure to obtain the violet reaction in anthrax blood is due to some defect in technique. He mentions that his films were fixed by '*passing three times through the flame of a Bunsen burner.*' This would certainly cause complete fixation and a negative result. The slide should be lowered, film side up, on to the top of the flame, for a second, so that the flame should not reach the film side but simply heat the under surface of the slide. It will generally be found that the reaction varies, in different parts of the film, in accordance with the degree of fixation. In the illustration attached, (A) shows where almost complete fixation

has occurred. Consequently, the capsule of the bacilli appears as a thin violet stained line. In (B), fixation was incomplete, and the bacilli are surrounded by a thick, disintegrating violet capsule. In (C), the fixation has been very slight and the violet-stained capsules are more swollen and disintegrated, and amorphous granules of the completely disintegrated capsules are seen lying apart from the bacilli.

There is no reason to suppose that the anthrax bacilli in India present any variation in virulence, staining reactions, or other biological characters, from those possessed by anthrax organisms met with in Europe or other countries.

In Europe, inoculated anthrax proves fatal to sheep, guinea pigs, rabbits, horses and cattle. In India, inoculated anthrax is equally fatal to these species of animals with the exception of cattle. When Indian cattle are inoculated with anthrax, they show a high temperature reaction, with slight local swelling at seat of inoculation, for three to four days - and recover. Very few cases have a fatal termination. Recently, through the courtesy of Sir John M'Fadyean, I obtained a culture of anthrax from his laboratory, with the object of comparing the virulence of the English and the Indian strain, in different species of animals in India. Both strains showed identical degrees of virulence. Sheep, guinea pigs and rabbits were inoculated with a like amount of a 18-hours' broth culture. The mortality, and the period from time of inoculation to death, were in each species very similar. In cattle inoculated from the English strain the reaction was identical with that from the Indian virus. No mortality among cattle resulted.

SOME OBSERVATIONS ON THE BACTERIAL RELATIONSHIPS OF CERTAIN SOILS, WITH SPECIAL REFERENCE TO THE CONTENTS OF ORGANIC MATTER.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S.

In order to endeavour to obtain a certain amount of insight into some of the various bacterial changes which take place in soils under the conditions obtaining at certain points in the Leeward Islands Colony, the work, of which an account is given in the following pages, was undertaken. In May 1912, small plots of land were set on one side at the experiment stations at Skerretts, Antigua; La Guérite, St. Kitts; the Grove, Montserrat; and the Gardens, Dominica; which were continuously kept free from weeds for periods of from one year to fifteen months. At the outset of the experiment, samples of soil were drawn from each plot and on them were determined the total content of organic carbon, the nitrogen and the calcium carbonate.* The duration of the experiment on each of the different plots is given below, together with the total precipitation occurring during the period of the experiment at each station.

Station.	Duration of experiment.	Total rainfall during period of experiment.
Skerretts, Antigua	15 months	51·20
Grove, Montserrat	12 ,,	53·82
La Guérite, St. Kitts	12 ,,	50·17
Botanic Station, Dominica ..	15 ,,	79·30

At the end of the period in question, fresh samples of soils were drawn from each plot and the nitrogen and organic carbon redetermined on them; lots of approximately one kilogram each of the original samples were also put up in dishes in the laboratory, covered with clock glasses, and kept continuously moistened in the dark for six months; at the end of which time the content of organic carbon, nitrogen and nitrate was redetermined.

The approximate physical composition of the various samples is shown in the subjoined table. The results given are not of samples drawn from the plots themselves but represent averages of the soil type prevailing in the localities where the plots are

* For the methods employed in determining the organic carbon and the carbonates readers are referred to the Report on the Soils of Dominica, 1902, or to the *West Indian Bulletin*, Vol. XII, p. 69. The nitrogen was determined by the modified Kjeldahl method, while the nitric nitrogen was determined by the Schloessing process.

situated, with the exception of the Dominica sample, of which the actual analysis is given, by reason of its tending to depart from the general soil type of lands at the station.

PHYSICAL ANALYSIS OF THE SOILS OF THE PLOTS.*

	A. Skerretts, Antigua.	B. Grove, Montserrat.	C. La Guérite, St. Kitts.	D. The Botanic Gardens, Dominica.
Stones	3·6	16·2	7·3	...
Coarse gravel ...	2·6	6·6	13·8	6·1
Gravel	5·6	8·7	23·1	5·0
Coarse sand ...	5·0	8·6	15·6	5·8
Medium sand ...	9·2	26·5	15·4	19·2
Fine sand ...	2·3	4·4	1·1	7·2
Very fine sand ...	3·7	5·0	2·4	5·3
Silt	7·8	6·5	3·3	4·9
Fine silt ...	14·1	13·1	11·4	36·8
Clay	9·4	·8	·7	1·5
Organic matter and combined water.	6·7	3·3	2·6	5·2
	100·0	100·0	100·0	100·0

It will be observed that the soils of the plots at St Kitts and Montserrat are of a light and open type; that at Skerretts Antigua is a stiff heavy clay soil, while that at Dominica is a medium loam.

* The method employed in making the physical analyses is the beaker method of Osborne. The sizes of the various grades of particles are as follows:—

	Millimetres.		
Stones	above	5	
Coarse gravel	5	to	2
Gravel	2	,,	1
Coarse sand	1	,,	0·5
Medium sand	0·5	,,	0·25
Fine sand	0·25	,,	0·1
Very fine sand	0·1	,,	0·05
Silt	0·05	,,	0·01
Fine silt	0·01	,,	0·005
Clay	less than		0·005

In the following table are given the chemical characteristics mentioned above in respect of the soils of each of the four plots in question, at the outset of the experiment :—

CHEMICAL CHARACTERISTICS OF THE SOILS OF THE PLOTS.

	A. Skerretts, Antigua.	B. Grove, Montserrat	C. La Guérite, St. Kitts.	D. The Botanic Gardens, Dominica.
	Per cent.	Per cent.	Per cent.	Per cent.
Carbon dioxide ..	0·0352	0·0105	0·0227	0·0305
Equivalent calcium carbonate	0·0800	0·0238	0·0516	0·0693
Organic carbon ..	1·087	0·964	1·028	1·170
Equivalent humus	1·874	1·661	1·772	2·017
Nitrogen	0·148	0·071	0·087	0·165

It will be observed that all the soils are deficient in calcium carbonate, and that each contains a moderate sufficiency of nitrogen and humus.

Below are given the data in respect of the fresh samples drawn from the plots at the expiration of fifteen months :—

	A.	B.	C.	D.
Organic carbon ...	0·570	0·745	0·720	1·150
Equivalent humus	0·983	1·280	1·241	1·983
Nitrogen	0·067	0·063	0·059	0·148

While the following table gives the values obtained in respect of the original samples after keeping in the laboratory for six months under the conditions detailed above :—

	A.	B.	C.	D.
Organic carbon ...	0·915	0·725	0·755	...
Equivalent humus	1·578	1·302	1·250	...
Nitrogen	0·116	0·071	0·088	0·141
Nitrogen as nitrate	0·0055	0·0052	0·0037	0·0023

From the above results it is seen that both in the laboratory and in the field the soils of all the plots show a decided diminution in the content of organic carbon. at the end of the experiment.

The magnitude of the diminution varies considerably in different cases; and also, in some instances, marked differences appear between the losses that have occurred in the laboratory and in the field.

With regard to the nitrogen content of the plots, while in two cases in the field marked decreases in nitrogen content are shown, the results obtained are markedly irregular.

The changes which have taken place are the results of bacterial action, and constitute an index of those which may occur in actual practice in the field. It is convenient to consider the results from each plot separately.

Taking first of all the results obtained in the case of trial A, Skerretts, Antigua; with regard to the content of organic carbon, sensible diminution has occurred both in the laboratory and in the field, in respect of this constituent; it is however to be noted, that the loss which has occurred in the field is considerably in excess of that which has taken place under laboratory conditions. In the former instance the diminution observed, amounts to 0·507 per cent. or very nearly one-half of the total original content; in the latter case the loss reached is only 0·172 per cent. or about 16 per cent. It must be remembered, however, that the duration of the experiment in the field was much greater than in the laboratory.

Somewhat similar results are recorded in relation to the nitrogen content of the soil, which both in the laboratory and in the field show considerable decreases.

In the field however, a much larger loss of nitrogen has again occurred than in the laboratory. In the former case the loss recorded amounts to ·081 per cent. or over 50 per cent. of the total: in the latter it is only ·052 or roughly 30 per cent. of the total.

Reference to the table of physical analysis shows that the soil is heavy and close-textured in type, and in the field conditions may probably have been such as to have favoured loss by denitrification, and it seems reasonable to suppose that this cause may be partly responsible for the effect. In the laboratory the loss observed is much smaller, and is probably accounted for by the addition of an excess of moisture at some time during the progress of the experiment.

That the moisture was not excessive throughout is demonstrated by the fact that quite an appreciable amount of nitrification has taken place.

In respect of trial B, Grove, Montserrat; the loss of organic carbon which has taken place is very nearly identical both in the field and in the laboratory, amounting to approximately just over one-quarter of the total amount originally present. It should however again be remembered, that the duration of the field trial is twice that of the laboratory experiment. so that in the latter case the loss has been very rapid, as is natural.

In respect of the nitrogen content, in the laboratory experiment the nitrogen content as determined by the Kjeldahl process

is identical at the beginning and end of the experiment; an appreciable amount of nitrification has however taken place, and a small gain in consequence is recorded. In the field trials the nitrogen as determined by the Kjeldahl process shows a decided diminution.

With reference to trials at La Guérite, St. Kitts, almost identical results are again recorded for the diminution of the organic carbon content both in the laboratory and in the field. Here again, however, owing to the greater duration of the field experiment the loss in the laboratory has proceeded at about twice the rate of the loss in the field. In respect of the nitrogen content no alteration is recorded in the laboratory, while a considerable loss took place in the field. In the laboratory appreciable nitrification has occurred. On the whole, the results are similar in character to those recorded in the case of the Montserrat samp'e.

With regard to experiment D, at Dominica, the loss of organic carbon in the laboratory experiment is not recorded; in the field trial it is much less than elsewhere. Small losses of nitrogen have taken place both in the field and the laboratory trials. The results seem to indicate that a much smaller degree of bacterial activity obtains in this plot than elsewhere: it is not clear why this should be, if it is so.

The results of the culture series, as a whole, indicate the rapid manner in which the content of soil organic matter tends to decrease as the result of bacterial action under tropical conditions, as exemplified at the experiment stations in the Leeward Islands.

The trials in the field show with some accuracy the changes which may be expected to take place when conditions of bare fallow are maintained. Although no direct evidence is adduced as to what occurs when the soil is occupied by crops, there is every reason to believe that the actual rate of decay will be at least equally rapid. On the other hand, it must be borne in mind that the growth of crops must always result in the accretion to the soil of a greater or less amount of organic matter, which will replace to a greater or less extent the losses which take place.

It is important to observe, that the rate of decay of organic matter may be as rapid on heavy as on light soils.

Modern views as to the functions of bacterial activity in relation to soil organic matter indicate that the evolution of carbon dioxide, to which its breaking down gives rise, is responsible for the liberation of plant food from the mineral complexes of the soil, and moreover supplies energy for the maintenance of activities in relation to the nitrogen cycle.

Also when the supply of organic matter is abundant, addition to the nitrogen content of the soil tends to occur through the agency of free nitrogen-fixing bacteria of the Azotobacter type.

In addition, the purely mechanical action of an ample supply of organic matter is of much importance, especially in relation to very heavy and very light soils, inasmuch as it tends to modify the undesirable effects which are liable to occur on soils of either type owing to their physical character.

The results afford direct evidence as to the correctness of the policy which has for a number of years past been advocated as the best method of treatment for both arable and orchard soils under tropical conditions. This amounts in practice to endeavouring to maintain and increase the content of soil organic matter in the efficient and at the same time the most economical manure.

In carrying this into effect, the regular application of liberal dressings of pen manure, compost or other forms of organic manure is a feature of prime importance. Long bare fallows would appear to be of doubtful utility if not positively objectionable, by reason of the considerable decay of organic matter which must take place during them. A sounder policy appears to be that of cultivating short period green dressing crops with a view to increasing the store of organic matter and nitrogen.

In relation to orchard cultivation, the utilization of growth of weeds which normally occurs, and which is periodically cutlassed back, is advocated and should be combined with the application of pen manure and mulches.

The maintenance of fertility on such lines is a problem which may and frequently does present difficulties of a practical character. The observations in question, however, appear to indicate the substantial correctness of the underlying theoretical considerations, and it must rest with planters themselves to face these practical problems and solve them in relation to the particular sets of conditions with which they are confronted.

In relation to the nitrogen contents of the soils of the plots, it is noteworthy in the laboratory experiments that notwithstanding the small content of calcium carbonate in the samples, in every case an appreciable amount of nitrification has taken place. In this connexion the suggestion has been made to the writer, by Dr. Watts, that possibly under certain conditions, and in the absence of adequate supplies of calcium carbona e, the ammonia formed in the process of ammonification may serve as a base for the neutralization of the nitric acid formed during the later stages of nitrification

This suggestion is illuminating and indicates a possible field for further investigation, which seems likely to be fruitful of results.

In the field considerable losses of nitrogen are recorded in the case of all the plots, but, with the exception of the soil at Skerretts, corresponding losses are not shown in the laboratory. It would seem to be indicated that in the case of the Montserrat, St. Kitts, and Dominica experiments, these losses may be accounted for by nitrification and subsequent leaching, the open character of the soil being favourable to these processes.

At Skerretts, on the other hand, the evidence appears to point to a considerable amount of denitrification having taken place.

SUMMARY.

1. To investigate changes likely to take place in soils under tropical conditions, small plots of land were subjected to clear weeding for periods varying between twelve and fifteen months

at the experiment stations in Antigua, St. Kitts, Montserrat and Dominica. At the outset of the experiment, the soils of the plots were sampled to a depth of 12 inches, and on the samples were determined the content of organic carbon, nitrogen, and calcium carbonate. At the end of the period the soils were re-sampled, and the organic carbon and nitrogen were re-determined. Lots of the original samples were also kept in the laboratory for six months under moist conditions, and at the end of that time the organic carbon, nitrogen and nitrate contents were also determined. The soils of the Dominica, St. Kitts and Montserrat plots are all light in texture, while that at Skerretts, Antigua, is stiff and heavy.

2. At the end of the experiment it was found that both in the field and in the laboratory considerable losses of organic carbon had taken place as the result of bacterial activity, the losses varying between 25 per cent. and 50 per cent., in the case of the Antigua, Montserrat and St. Kitts samples : at Dominica, only a small loss is recorded.

3. With regard to the nitrogen contents, considerable decreases are seen in the field in the case of the Antigua, St. Kitts, and Montserrat samples ; in the case of the Dominica sample, the loss is small. In the laboratory, an appreciable loss of nitrogen occurred in the case of the Antigua soil ; in the case of the Montserrat and St. Kitts samples, no loss was observed, while the Dominica sample showed a small loss. All the soils exhibit nitrifying power : this is greatest in the case of the Antigua and Montserrat samples and smallest in the case of that from Dominica.

The losses of nitrogen which occur in the field is attributed to nitrification and subsequent loss by leaching at St. Kitts and Montserrat, and probably in some measure to denitrification at Antigua. In view of the small content of calcium carbonate, the suggestion has been put forward that ammonia formed in the course of ammonification may serve as a base for the neutralization of a part of the nitric acid formed in nitrification.

4. The results emphasize the high degree of bacterial activity existing in tropical soils, and indicate the necessity of maintaining an adequate supply of organic matter. In this connexion it affords direct evidence of the correctness of the policy followed by the Imperial Department of Agriculture in advocating the liberal employment of organic manures, such as pen manure, combined with the growth of green dressings in the case of arable crops, and the application of mulches and pen manure together with the utilization of grass and weeds by cutlassing in the case of orchard soils.

In conclusion, acknowledgement must be made of the assistance rendered by Messrs. V. M. Weil, B.Sc., and R. E. Kelsick, senior and junior assistants at the Government Laboratory for the Leeward Islands, in the performance of the analytical work recorded in this paper.

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A VETERINARY SURVEY OF THE WINDWARD AND LEEWARD ISLANDS.

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INTRODUCTORY.

During the past three years it has been the duty of the writer to investigate and report upon the various aspects of animal industry, with particular attention to the diseases met with in live stock, in the several islands of the Windward and Leeward colonies. It is not proposed in these notes to enter into any discussion as to the relative merits or demerits of the different methods of keeping, feeding, or breeding stock, nor upon such other matters as the improvement of pastures and water-supply, but rather to confine attention to the diseases affecting live stock, their parasites, and methods of control in each case, while reference is also made to the questions of meat and milk production, their inspection and control. The laws and regulations in force against diseases of animals are also noted and commented upon.

Specific diseases are met with in the several islands to a markedly different extent. Anthrax has been known in St. Vincent for many years but it is now completely under control, no cases having been discovered since July 1911. Its control is chiefly due to vaccination and adequate disposal of carcases. Anthrax has also appeared in Grenada, where an outbreak in 1911 was soon got in hand ; the disease has also been reported

from Nevis. From accounts of symptoms given there is reason to suppose that quarter-evil is also known, and it is a possibility that the disease in Nevis was this and not anthrax.

Texas fever was suspected to have broken out in Grenada but the evidence put before the writer was not sufficient to enable him to verify the diagnosis. It is somewhat remarkable that although the carrier of Texas fever is abundantly present in all the islands, no case of disease resembling Texas fever has been seen in the Windward and Leeward Islands. Accounts have also been heard of cases of abortion in cows which led to the conclusion that the condition was that of contagious abortion, but no instance has occurred which admitted of verification.

Skin disease of cattle in Antigua has caused losses in past years but it now appears that its effects are not so marked and that its incidence is lessening. This disease is dealt with in a separate communication.

Tuberculosis in cattle is met with in many islands where a few old cows appear to be affected, but in Antigua the disease is rampant and is annually the cause of much loss amongst stock; it also greatly impairs the efficiency of the working oxen in that island.

Among equidæ, perhaps the disease most commonly found is Epizootic lymphangitis. This disease, which affects donkeys, mules and horses in the order named is often met with in Antigua and many cases occur in other islands

Tetanus occurs somewhat frequently in all the islands, horses and mules being chiefly affected. Other diseases met with include Botriomycosis, in the form of shoulder-tumour and Scirrhous cord, strangles, navel-ill, aphtha of lambs, and an infectious ophthalmia of cattle. Septicæmia and Pyæmia are of common occurrence, often as a result of neglected wounds and other injuries.

Amongst dogs, distemper is to be seen; rabies has not been observed in the Windward and Leeward Islands by the writer, but it appears to be occasionally present in the neighbouring island of Trinidad.

Turning to the diseases non specific in origin, there is a remarkable absence of diseases of the lungs and pleuræ, while alimentary and surgical diseases do not differ in essentials from those met with in other parts of the world.

Parasitic diseases are very common, and exert a considerable influence on the well-being of live stock. Hoose—verminous bronchitis—is common and is to be met with in most of the islands in cattle, sheep and pigs. In cattle, *Strongylus micrurus*, Mehlis., is the parasite concerned, in sheep *Strongylus filaria*, Rud. and in pigs *Strongylus paradoxus*, Mehlis. In pigs the parasite may be present to a surprising extent without bringing about much change in condition.

Oesophagostomiasis is one of the most troublesome diseases of live stock in the West Indies, and is met with in almost all the islands. In cattle and sheep it is a fertile cause of death, particularly, as in the case of many cattle seen by the writer,

where hoose is co-existent. Nodular disease of the intestines of sheep is caused by *Oesophagostomum columbianum* Curtice, and is a very common slaughter-house condition. The writer has observed a similar condition in a pig. *Oesophagostomum inflatum*, Sch., is the parasite of the ox, and affects particularly calves and young animals. *Oesophagostomum venulosum*, Rud. occurs in Dominica, in addition to *Oesophagostomum columbianum*, Curtice, of sheep, and *Oesophagostomum dentatum*, Rud. of pigs in the other islands.

The screw-worm, the larva of *Chrysomyia macellaria*, does much damage in wounds and the navels of young animals, if neglected, but its control is easy.

Sarcoptic mange has been met with in horses, mules and donkeys, and ringworm has been commonly seen on young calves.

Ticks constitute the greatest source of trouble to live stock. met with in the West Indies and are a scourge to the stock industry.

The common or 'Creole' cattle tick is the *Boophilus australis*, Fuller, and this tick is present in enormous numbers in all the islands. The *Dermacentor nitens*, Neum. is the common tick found in horses in the several islands, while the tick commonly found in dogs is the *Rhipicephalus sanguineus*, Latr. In addition to these species the fowl tick, *Argas persicus*, Wald., has been found, and in Antigua alone there exists the *Amblyomma variegatum*, F. of cattle, which is a large tick of a genus usually associated with Africa.

The meat industry on the whole in the Windward and Leeward Islands is not in a satisfactory condition. In the chief towns of St. Vincent and Antigua proper slaughter houses exist, and proper inspection of meat obtains. In the chief towns of the other islands, however, and in the country districts generally no adequate inspection takes place. The demand for meat is small, and it is a common practice for planters to kill their own animals. selling the meat to neighbouring planters and to the labourers.

The milk supply is haphazard in most cases, and usually the only attempt to produce milk on scientific lines is made by those who have contracts to supply the Government institutions, such as the hospitals. Otherwise it may be said, speaking generally, that the milk supply is in the hands of the peasants.

Consideration will now be given to the principal features of veterinary interest that have come under observation in the several islands.

GRENADA.

Grenada is a cacao-growing island consequently the number of animals required on the estates is less than that of a sugar-growing island.

Both cattle and mules were used for hauling purposes, and donkeys on account of their small size are much employed for carrying the cocoa-beans through the cocoa to the curing houses. Horses are mainly used for saddle and driving purposes while a flourishing Race Club accounts for the presence in the island of some dozen or more thoroughbred and half-bred horses. Small

stock, sheep and goats are raised in some parts of the island not adapted to cultivation. Pigs are kept both on the estates and by the peasants but no organization exists in their management, and the numbers are few.

Diseases amongst stock are happily not very serious; ticks and other parasites constitute the greatest drawback to animals. Of specific diseases, anthrax has occurred within recent years. The writer proceeded to Grenada in October 1911 in consequence of an outbreak which was responsible for the deaths of about a score of animals, including mules and goats. One estate was quarantined and movements of stock were prohibited. A glebe pasture in the town of Gouyave was also declared to be an infected area, in consequence of two goats having died of anthrax on it. This pasture was fenced and stock were kept from it. The buildings on the quarantined estate were disinfected and the usual precautions as to disposal of carcases were strictly enforced. After a lapse of some few weeks quarantine was raised and the disease has not since reappeared, with the exception of the death of one goat, which some months later strayed on to infected land. The outbreak thus appears to have been completely checked.

Epizootic lymphangitis is present in the island, mostly amongst mules and donkeys and it appears to be on the increase: at present its incidence, however, is not great. A leaflet on this subject is being prepared for distribution among stock-owners.

Early in 1913 an outbreak of disease occurred, which was supposed to be Texas fever. When the writer was able to reach Grenada, no case of the disease was to be seen, and the means of first hand diagnosis were not available. From the evidence at disposal, consisting of clinical examination of recovered animals, accounts of symptoms from various observers, and the limited effect and extent of the outbreak, it was not found possible to confirm the diagnosis, and the quarantine which had already been imposed was removed. No return of the disease has since been experienced.

An infective ophthalmia of cattle has occurred at intervals. In this connexion a leaflet was prepared by the Government from a publication of this Department, and issued to the stock-owners.

Amongst the parasitic affections of animals greatest prominence must be given to ticks, which infest all animals in vast numbers. In the late summer and autumn particularly their effects are severely felt. The names of the species occurring have already been given in the preceding section. Internal parasites are also commonly met with, and, especially in small stock, are a serious menace. Oesophagostomiasis and tape-worm infection by *Taenia* (Monieza) *expansa*, Rud., appear to be the most common.

The meat and milk supply of the island stand in need of considerable improvement. There is no inspection of meat in the town of St. George, nor in the smaller towns of Gouyave, Sauteurs, and Grenville where meat is also sold. Slaughtering is done at night, under no supervision, with the exception of that of an untrained market clerk who may or may not be present. The

milk supply is not organized and with the exception of the contractors who supply milk to the Government institutions, no attempt is made to keep the cows on anything approaching to a dairy scale. There exists no law in this connexion to enforce cleanliness or to prevent adulteration.

The control of animal diseases is provided for under The Contagious Diseases (Animals) Ordinance, 1905, (No. 8 of 1905). This Ordinance meets most of the requirements of the Colony in regard to contagious diseases of animals, particularly as the Governor-in-Council is given the power to make orders under this Ordinance for the prevention and checking of disease and other purposes, thus retaining power to make any further regulations which may be deemed necessary since difficulty may arise from the fact that the Colony possesses no Government Veterinary Surgeon.

The Anthrax Order-in-Council, 1908, was drawn up to meet an outbreak of anthrax; the provisions are sufficient for the objects in view. Power is however given to move any horse, ass or mule which is not diseased from the infected area to any place. As there is no power to stop them coming in again into an infected area they may conceivably be the means of spreading the disease. This is the weak point in the order but it is apparently permitted so as to impose as little hardship as possible upon planters, during the cacao crop.

The importation of animals is regulated under The (Foreign) Animals Importation Ordinance, (No. 9 of 1908). This act is fairly comprehensive and includes regulations regarding fodder, litter, hides and other products. It appears to be adequate.

ST. VINCENT.

In this colony the cultivation consisting mainly of cotton and arrowroot does not require very many animals. Cattle are used for draft purposes on all the estates, more particularly on those few estates which grow sugar. Horses are mainly confined to riding and driving purposes. Small stock receive a certain amount of attention in some parts of the island. Pig rearing is carried on to a limited extent on estates and is taken up to some extent by the peasantry.

The most serious disease which has been known in St. Vincent is anthrax, and the losses were so severe that in 1906 a Government Veterinary Surgeon was in consequence appointed. The disease had undoubtedly existed in the island in enzootic form for many years, and within recent times, serious outbreaks had occurred in 1899 and 1900 and the following years. It was not until 1905 however that proper regulations were made for disposal of carcases, and a systematic examination of the blood of dead animals carried out by the late Dr. C. W. Branch. In August of 1906 a Government Veterinary Surgeon was appointed who is still resident in the island. Professor Annett was brought from England to investigate and advise on the conditions. In his report dated January 13, 1907, the following suggestions were made.

1. Compulsory notification of all deaths amongst live stock should be enforced.

2. One ear of all dead animals should be sent in to the Government Veterinary Surgeon in a special metal case, in order to enable microscopic examination of the blood to be made.

It was found that in those districts far removed from Kingstown, the ears were of very little use for diagnostic purposes, and blood-smears were therefore substituted.

3. Regulations for the adequate disposal of carcases should be put into force.

4. Vaccination as a preventive measure coupled with branding of vaccinated stock should be at once instituted.

The vaccine used was a double vaccine prepared in England under the personal supervision of Professor Annett. The vaccination was carried out free of charge, but purely as a voluntary measure. These preventives had a marked effect and the death rate from anthrax soon showed a steady decrease. In 1908 fees were charged for vaccination and in 1909 there was a decrease in the number of small stock vaccinated and a rise in the number of cases of anthrax, which was followed by a pronounced fall in 1910, and a further fall in 1911. It is probable that this diminution is partly due to the fact that the extension of the cotton industry led to many anthrax infected pastures being converted into cotton fields; but the energetic measures taken by the Government are largely responsible for the complete mastery of the disease which appears to have been attained. It is to be recorded that no case of anthrax has been reported in St. Vincent since July 1911, a period of nearly two years.

The writer during six weeks in April and May 1912 had the opportunity of examining all the blood-smears and ears sent in, and found no case of anthrax during that period. It may now be concluded that anthrax in St. Vincent is fully under control and practically stamped out; references to the disease will be found in *West Indian Bulletin*, Vol. VI, pp. 156 *et seq.* and Vol. XII, p. 72.

Other specific diseases are found but rarely. Very few cases of tuberculosis have occurred as evidenced by the slaughter-house returns and one case of actinomycosis has been noted.

Parasites are the cause of much trouble. Ticks are met with very plentifully on all stock and none but inadequate measures are employed to deal with them. On some of the more extensive estates where the pastures are far removed from the works, the stock are only penned once or twice during the week, and the only attempts to remove the ticks are made then.

Of internal parasites, the oesophagostomes and hoose worms are by far the most important. They are to be seen particularly in small stock, but they are found in cattle also. In sheep the *Oesophasgostomum columbianum*, Curtice, which causes the nodular disease of the intestines is common; and in pigs almost 50 per cent. of the subjects slaughtered at the abattoir are found to be hosts of the *Strongylus paradoxus*, Mehlis, or hoose worm. These two parasites are considered of sufficient importance to warrant their treatment in separate articles. Oesophagostomiasis has already been dealt with in the *Agricultural News* (Vol. XII, p. 149). Hoose will be dealt with in a later issue. Other parasites

found are *Echinorrhynchus gigas* (Goeze), *Oesophagostomum dentatum*, Rud., *Stephanurus dentatus*, Dies., in pigs. *Sclerostoma equinum*, Duj., *Filaria papillosa*, Rud., *Oxyuris curvula*, Rud. in horses, and the *Strongylus micrurus*, Mehlis, in the ox. An article on these is published in the *West Indian Bulletin*, Vol. XIV, No. 2.

The meat supply of Kingstown, St. Vincent, is organized on a proper scale and by proper methods. A slaughter-house, which has been somewhat improved upon suggestions made by the writer, is controlled by the Kingstown Town Board, and all meat slaughtered there is examined by the Government Veterinary Surgeon. A building of the public market is set apart for the sale of the meat, and altogether the conditions of meat supply are satisfactory. In the other towns, e.g. Georgetown, there is no qualified inspection and no strict supervision. In April 1912 by-laws were made under 'The Kingstown Board Ordinance 1897,' to regulate the working of the abattoir and market.

The milk supply is not in the same satisfactory condition but it may be noted that the matter is at present engaging the attention of the Government with a view both to ensuring a cleaner supply and preventing adulteration.

In 1869 'The Cattle Diseases Prevention Act, 1869' was passed, its objects being to prohibit the importation of animals for the purpose of preventing the introduction of disease, and to prevent its spread in the Colony.

'The Anthrax Ordinance 1911' provides for the compulsory vaccination of animals as a precaution against anthrax in infected districts. It is probable, however, that, owing to the complete control obtained over this disease, it will not be necessary to put the provision of this ordinance into force. Sporadic cases of anthrax may occur from time to time, but with the knowledge of the disease now possessed by many stock-owners, and with the assistance of the Government Veterinary Surgeon, it should be a simple matter to keep it in check.

St. Lucia.

The cultivation in St. Lucia is mixed, sugar, cacao and limes all being grown. Stock in any number are therefore only to be found at certain places in the island, a few breeding establishments also exist. Some little attention is also paid to small stock.

The island appears to be comparatively free from diseases of animals. No case of epizootic disease came under the notice of the writer during a period of six weeks spent in the island and none have been reported to the Imperial Department of Agriculture. There was reason to suspect in one or two cases, the presence of tuberculosis, but these were old cows, and no evidence of the disease was observed among the young stock.

Parasites, external and internal, are here again the greatest cause of trouble and loss to stock-owners. Of the external parasites ticks are the most prominent, and no attempt on sound lines is made to control or eradicate them. Parasitic mange (*Sarcoptes scabiae*) was seen in mules and donkeys in a few

isolated cases. Neglect had permitted the area of infection to become extensive and the condition of the affected animals to become poor.

A parasite which at one time was the cause of considerable loss in young lambs, and of much trouble in other animals, was the screw worm, the larva of a fly, *Chrysomyia macellaria*, F. This fly lays its eggs in wounds and other raw surfaces such as the navels of young lambs with the result that the larvae cause much discomfort if neglected loss of the animal may be experienced. This parasite is dealt with in a Pamphlet issued by this Department, No. 14, (The Screw Worm in St Lucia) and the recommendations for treatment given therein are found to be both simple in application and efficacious.

Internal parasites are also found to have serious effects The chief class is undoubtedly the Oesophagostomes. Two varieties are known in St Lucia, the *Oesophagostomum columbianum*, Curtice, causing nodular disease in the intestines of sheep and the *Oesophagostomum inflatum*, Sch., in calves. The reader is again referred for further information to the *Agricultural News*, (Vol. XII, p. 149).

The meat supply has received attention in late years, and the Castries Town Board has addressed a communication to the Government on this matter. At the present, inspection is carried out by a layman who has an appeal to the medical officer of health in any case disputed by the butchers. This system is more or less satisfactory but it is nevertheless one which is by no means perfect. The employment of a duly qualified veterinary surgeon for this and other duties was suggested by this Department, but on account of the expense it was decided to postpone the question In the smaller towns and villages there is no inspection.

The milk supply is not in any way controlled and is consequently not good.

The laws of St. Lucia relative to the diseases of animals are contained in No. 1 of 1906, 'The Contagious Diseases (Animals) Ordinance, 1906' and the Contagious Diseases (Animals) Ordinance, 1906, Amendment Ordinance, 1908. The main ordinance appears to be adequate with regard to control of diseases; the Amendment Ordinance gives power to prohibit the importation of animals, fodder and litter.

DOMINICA.

This island being mostly concerned in the cultivation of limes, and very few working animals are required. On sugar estates, of which however only a few exist, a few horses, mules, cattle and donkeys are to be seen. Small stock are also met with in certain parts of the island.

Of specific diseases, the only one which came to the notice of the writer during a short visit was Epizootic lymphangitis, and this in but few cases. It is probable, however, that many cases exist. This disease is dealt with in a separate paper.

Parasites and parasitic diseases again compel attention. Of the external parasites ticks are the most troublesome pest and

are to be found abundantly on all animals. Internal parasites cause much loss, especially amongst small stock. Oesophagostomiasis, known locally as 'la gomme' is responsible for many deaths of sheep in some parts of the island. (See *Agricultural News*, Vol. XII, p. 149.) Dominica is fortunately on the whole comparatively free from disease amongst animals, and the chief considerations of stock-raising are to be found in minor conditions and accidents.

The meat supply of Roseau, the chief town, is in need of considerable improvement. The writer paid several visits to the slaughter-house and was able to observe many points, both in the arrangement and working which appeared in urgent need of improvement. The conditions of working were found to be filthy and there was a lack of proper inspection of meat. The conditions, together with suggestions for effecting improvements were reported to the Imperial Commissioner of Agriculture who directed the attention of the Local Government to the matter. It is to be regretted that up to the present, little or no change has taken place.

The milk supply is in the same haphazard condition. No regulations are in force to control the sale of milk, to prevent its adulteration, or to promote cleanliness in its handling. As is to be expected under the circumstances, there is much room for improvement. It is expected, however, that these matters will soon be ameliorated; provision has been made for the establishment of a local chemical laboratory where milk and other foods may be examined, and it may be anticipated that regulations will be drafted for controlling the sale of milk and kindred matters so soon as the machinery exists for enforcing them. The laws of Dominica relating to live stock consist of 'The Contagious Diseases (Cattle) Act, 1877' (No. 14 of 1877). This act, however, does not include horses, mules and asses, and other animals though these are referred to and included in certain sections notably section XII prohibiting importation.

MONTSERRAT.

The number of stock in Montserrat is limited. The majority of estates are concerned in the cultivation of limes and cotton, but in one or two instances, many animals are bred, both for local use and for export.

Montserrat is fortunate in its freedom from disease. No case of specific disease has been observed by the writer during two short visits, and there are no records of serious outbreaks of disease in animals. The usual troubles are met with, in dietetic disturbances and accidents Parasites also do not appear to exert so malignant an influence. Ticks are present but are not the carriers of specific disease; as in some of the other islands, little appears to be done to effect their eradication. The oesophagostome, which seems to be present throughout the islands of the West Indies, has not been actually found in Montserrat, but from descriptions given in answer to questions, it seems certain that the parasite is present and shows symptoms in sheep in common with those seen in other islands.

Legislation with regard to animals is provided for in No. 3 of 1877—'Cattle and Animals Prohibition and Regulation of Landing Ordinance, 1877' and in No. 3 of 1888 'An Ordinance to Make Provision for Prohibiting the Importation of Goods from Localities where epidemic diseases of contagious or infectious character prevail.' These ordinances, however, do not deal with outbreaks of disease for which there is no provision, but only with importation.

ST. KITTS.

In this island there are numbers of animals on the various sugar and cotton estates, cattle being chiefly concerned in the cultivation. Horses are used for saddle and driving purposes and a few are mainly kept for racing. Small stock do not as a rule receive much attention.

Epizootic diseases are few and in no case have their effects been marked. In 1910 an outbreak of disease which was diagnosed as anthrax occurred in Nevis, and one or two cases, similar in symptoms and resulting in the death of the animal came under notice in St. Kitts. Precautions as to the burial of carcases and disinfection were taken and no more cases of the disease occurred; and no further cases have since been reported

A disease which caused many deaths in past years is that known locally as bookburn. No case of this disease has come under the writer's notice during two short visits to the island, but from information gleaned from various sources, it appears that the cause of the disease is to be found in one of two possibilities. The first is by poisoning with wild Ipecacuanha (*Asclepias Curassavica*) which is commonly found in some of the pastures. This would appear to be negatived by the fact that in experiments undertaken by the St Kitts Agricultural and Commercial Society quantities of this shrub fed to a cow both in the natural condition and by infusions did not cause death or even any untoward symptoms. The other possible cause is that of eating dry fodder from the pastures which produces a simple impaction of the omasum. There is some evidence which tends to prove the correctness of this view, and the symptoms are in accord with it. A more laxative diet in seasons of drought, when all available fodder is coarse and dry would seem to be indicated. This may be in part attained by the more liberal use of molasses.

Other diseases noticed were the usual dietetic and surgical conditions.

Parasites are an important consideration Ticks are present in abundance on all classes of live stock. In St. Kitts there appears to exist the opportunity of eradicating ticks systematically by means of dipping or spraying, as is being attempted in Antigua. The cost of say two machines, one at each end of the island, if shared by those interested would not amount to any excessive sum, and the actual cost of spraying animals would not exceed 1s. 6*d*. per head per annum. The benefits to be derived are too obvious to require recapitulation.

Of internal parasites, most harm appears to be done by the hoose worms, which are the cause of considerable loss, particularly

of small stock on some estates. It is of interest to note that no case of oesophagostomiasis was seen, but it is thought that the disease nevertheless exists. Tape-worm infection was also met with in small stock. In one lamb killed for food at the public slaughter-house, Basseterre, there were upwards of twenty tape worms, *Monieza* (Tænia) *expansa*, Rud.

The subject of meat inspection in St. Kitts requires some consideration if the arrangements are to be brought up to date. The chief objection at present lies in the fact that the slaughter-house is not enclosed and is in fact divided into two parts by a public road. Inspection in the past has been more or less adequately carried out by a lay inspector, who has charge of the working of the slaughterhouse and market. Killing here is done in the evenings, instead of the usual practice of killing in the early morning. It is worthy of note that the Government and planters combined are at present endeavouring to secure the services of a Veterinary Surgeon one of whose duties will be the inspection of meat.

The milk supply is not organized and is, as is usual in the West Indies, left in the hands of the peasants. Provision has been made for testing of milk for adulteration for a nominal fee but practically no use has been made of this by the general public. It is in contemplation by the Government to establish a branch chemical laboratory in St. Kitts primarily for agricultural purposes, and provision will be made for the examination of milk and other food and it may be anticipated that regulations in this connexion may soon be in force.

St. Kitts is singular in that it appears to have no act or ordinance relating to the diseases of animals or their importation. In the past there appears to have been an absence of epizootic diseases, but it may be necessary in the future to legislate with regard to animal diseases, and in absence of an ordinance may be keenly felt.

Nevis.

Nevis is chiefly occupied in the cultivation of cotton and sugar; some estates are devoted almost entirely to stock raising. An outbreak of specific disease, probably anthrax, occurred in September 1910 which on two estates caused the deaths of ninety animals. Mr. W. R. Dunlop, then Science Master at the Government Grammar School, St. Kitts, investigated the matter and he examined the blood smears and also submitted them for examination to a medical officer. They were of the opinion that the disease was anthrax. Instructions were given as to the disposal of the carcases and disinfection of premises, but vaccination as a preventive measure, though suggested, was not adopted. These measures were responsible for the abatement of the disease and no recurrence has been experienced. When the writer visited the island in July 1911 no case of the disease had been noticed since the primary outbreak. Enquiries however elicited information which, while partly appearing to confirm the diagnosis of anthrax, yet aroused the suspicion that not all the cases were of that disease, but some at least may have been due to black quarter or quarter-evil. It would be well perhaps in

event of further outbreaks to have this fact borne in mind as a possibility.

No cases suspicious of any specific disease were seen by the writer, but the usual experiences of non-specific diseases and surgical conditions were encountered.

Parasites are present in the island in considerable numbers. Of the external parasites ticks were found to be abundant on all stock and their effects were very obvious, particularly so, when a long drought had militated against the good condition of the animals.

Amongst internal parasites the hoose worm is known to cause considerable loss, especially of calves (*Strongylus micrurus*, Mehlis.); in certain seasons the incidence of infection is said to be very large.

The Laws relating to the diseases of Animals in Nevis will be found in No. 5 of 1877 The Contagious Diseases (Cattle) Act, 1877. This act while being more or less adequate requires bringing up to date. It prescribes burial under 6 feet of lime for animals dying of disease, whereas, particularly dealing with anthrax, cremation is the more efficient means of disposal.

ANTIGUA.

Antigua is a sugar-growing island and the number of stock employed on the estates is somewhat larger than in other islands. In addition to this, the island is less mountainous and is subject to prolonged periods of drought. Diseases of stock, too, are on the whole more prevalent and the effects of the disease apart from death, more noticeable.

Specific diseases are present in some cases, in serious proportions. The chief importance must be given to tuberculosis amongst cattle. In 1911, the writer observed that the disease was clinically evident in many parts of the island. A somewhat peculiar feature was the production of large glandular 'shoulder tumours' which were supposed to be due to injury connected with the yoke, but which were proved, both microscopically and by reaction to tuberculin to be tuberculous.

A series of tests for tuberculosis by means of tuberculin was carried out with the co-operation of the Government in 1912 and it was found that of 162 cattle tested, including bulls, cows and working oxen, thirty-seven or 23 per cent. were affected. This somewhat large proportion of reactors which it must be remembered were found amongst animals selected for testing and therefore presumably containing many indications of being affected drew attention to the seriousness of the infection and recommendations were made with a view to the control and ultimate eradication of the disease. Some estates were found to be affected to a much greater extent than others. On two estates, further tests were subsequently made embracing the whole of the cattle and it was found that the results confirmed those of the previous test. The figures on one estate show that 30 per cent. of all cattle were affected; on the other positive reactions were obtained in 45 per cent. of cases, while a mistake in the time of taking temperatures resulted in a large number of

the reactions being classed as doubtful, many of which are almost certainly positive. Thus the probability is that on this estate the percentage of reactors is well above 50.

It is pleasing to record that the owners of these two estates are endeavouring by segregation and other means to combat the disease, but it is a matter for regret that an apathetic attitude is adopted by the majority of owners Many deaths amongst cattle, which are at present put down to various other causes, will in the opinion of the writer, be found on investigation, to be due to this disease. The results of the series of tests previously alluded to, will be found in the *West Indian Bulletin*, Vol. XII, p. 187. A report was made to the Commissioner of Agriculture and communicated to the Government of Antigua on January 10, 1913. This report was printed for local circulation. A review of this is given in *Agricultural News* (Vol. XII, p. 187).

Another disease of cattle which in the past has been said to cause many deaths is the so-called skin disease. Its effects are apparently much less felt in the island than was formerly the case and it is the present experience that cases are comparatively rare; this may be determined to some extent by the drought of recent years, and a recrudescence may not be impossible if a series of wet years should supervene. The cause of the disease is not yet definitely established, but the view may be expressed in the opinion of the writer that the 'gold' tick (*Amblyomma variegatum*, F.,) is not concerned in the transmission biologically, but if it is concerned at all its rôle is merely mechanical. This disease has lately been the subject of investigation, and further consideration is given to it in a note to be published shortly. It is worth pointing out at this stage that there is a strong probability that the use of arsenical washes for the control of ticks, in a manner referred to in a subsequent paragraph, will incidentally tend to reduce the prevalence of skin disease which may thus cease to be a cause of serious trouble.

Equidæ in Antigua, particularly the mules and donkeys, are affected, to a not inconsiderable extent with Epizootic lymphangitis This disease is locally known under the name of erysipelas and has been present in the island for many years. No steps appear to be taken under existing laws to prevent contamination by it, and no attempt appears to be made by owners to restrict its spread.

Strangles occurs somewhat rarely, especially amongst young horses, but its effects do not appear to be very severe.

Botriomycosis is present in the shoulder tumour of Equidae. Mules are affected as well as horses, and surgical interference is apparently the best means to adopt in order to remedy the condition.

It was at one time supposed that glanders existed in Antigua, and was responsible for many deaths. From available evidence, however, it would seem that an error of diagnosis occurred, and the cause of the deaths referred to must be looked for in something else.

Sheep suffer on occasion from what is undoubtedly an infectious aphtha. This results in sores on the teats of the sheep

which are easily and naturally transmitted to the mouths of young lambs. The exuberant growth of warty tissue which occurs prevents sucking and they also occlude the nasal passages; in some seasons many deaths are caused thereby.

Parasites in Antigua are perhaps more numerous and more severe in their effects than in the other islands.

Ticks are the most troublesome external parasites met with. The creole tick (*Boophilus australis*, Fuller) is abundantly present on cattle, while a much larger tick (*Amblyomma variegatum*, F.) is also to be found on cattle. This tick is found only in Antigua of the British Islands, but is recorded as existing in Guadeloupe, to which island it was supposed to have originally been brought from Senegal. Its economic importance apart from its incidental effects of tick infestation lies in the fact that it is supposed to be concerned in the transmission of the skin disease of cattle previously mentioned. Further notes on this tick will be found in an article appearing under the heading 'Notes on some Parasites of Live Stock in the West Indies' in the *West Indian Bulletin* (Vol. XIV, No. 2).

It is but meet that the island which suffers most from the ravages of ticks should be the first to make an attempt to deal with ticks in an organized and systematic manner, with a view to their ultimate eradication. A spraying machine has been erected by private enterprise, which is doing good work, and it is hoped that the successful results attendant upon its use will be a sufficient incentive to other owners to emulate this example.

The reader is referred to an article appearing in the *West Indian Bulletin* (Vol. XIV, No. 2) for a description of the machine and its working.

It is beyond doubt that the erection of a sufficient number of these machines, or of dipping tanks, scattered through the island, would in a few years be the means of eradicating ticks. It would be necessary, however, to provide facilities for the treatment of peasants' stock, and to pass an ordinance making treatment compulsory. Pastures will also require attention; it would be necessary to fence the pastures and to rest parts of them at intervals. Any expense borne and any hardship entailed would be fully repaid in a very few years, by the better condition and increased efficiency of the stock.

Among internal parasites the more important are certainly the hoose worms, causing verminous bronchitis, and the oesophagostomes. It is not uncommon to find the two parasites together in the same animal and many deaths have resulted from the severe parasitism produced. Cattle appear to suffer from hoose more than small stock, and in certain parts of the island much harm is done to young calves by these parasites and death has been caused in many cases. The oesophagostomes are found as parasites of cattle and of small stock, and are the means of creating parasitism of a very severe nature, in many cases death. Taeniae are also partly responsible for a cachexia which is also seen especially in small stock. The chief agent is probably *Marieza expansa*, Rud.

The inspection of meat is in the hands of a Government Veterinary Surgeon and is fairly well organized. No returns

are however available, and the incidence of diseases, and of parasitic infection is not obtainable. The slaughterhouse is well equipped and though separated from the market is enclosed within it; it is well regulated.

The milk supply is at the present time receiving attention and samples of milk are being analysed at the Government Laboratory. It is hoped, as a result, that regulations will be enforced to ensure cleanliness and prevent the adulteration which at present occurs. The laws relating to diseases of animals are contained in No. 16 of 1913, 'The Diseases of Animals Ordinance, 1913'. This ordinance has recently been passed by the legislature, at the instance of this Department: it is based on a model act which has been compiled to meet local requirements. The act was based largely on the act then in force in Antigua, (No. 11 of 1900) it is now considered to be comprehensive and complete, and might serve as a model for consideration in neighbouring islands.

EPIZOOTIC LYMPHANGITIS.

BY P. T. SAUNDERS, M.R.C.V.S.,

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This disease may be defined as a specific contagious disease characterized by a suppuration of the superficial lymphatics and is due to a specific organism which is a fungus.

The disease has been present in many islands of the West Indies for some considerable time, and the tendency at present appears to be towards an increase in its incidence. This may be in great part due to the fact that animals suffering from the disease are able to perform their work nominally, and there is a good deal of reluctance on the part of owners to adopt the necessary measures for prevention when the animal is otherwise in fair general health.

The animals affected are confined to the Equidae, asses, mules and horses, being affected in the order named. The disease has also been known in the ox, but rarely.

The disease has been known for upwards of a century but was confused with Farcy till 1865. It was first described by Italian and French veterinarians and the specific organism was discovered by Rivolta in 1873: it has been found to exist in France, Italy, Sweden, Finland, parts of Russia, Egypt, Algeria, in the Malay States, and Japan, also in Mexico, and in some states of the United States of America. It also occurs in South Africa, and was introduced into the British Isles by horses returning from the South African war.

The disease is alternatively known as Mycotic lymphangitis in America. Previous names assigned to it include River farcy; African farcy, Japanese farcy, or Pseudo-farcy.

ETIOLOGY. The cause of the disease is *Cryptococcus* (saccharomyces) *farciminosis* belonging to the order Saccharomycetes or yeasts. It is apparently an obligatory parasite, and is difficult to cultivate on artificial media.

MORPHOLOGY. The cryptococci are oval or pear-shaped bodies about four microns in length and two to three in breadth. Under a comparatively low power of the microscope it can be seen that it has a double-contoured envelope; both envelope and contents are colourless. Often one pole is pointed and at the other pole a bud or small protusion may be seen. It is by the formation of these buds that propagation is effected.

STAINING REACTIONS. The organism stains with any common dye but gives up its colour readily, as even water seems to wash it out. Claudius' method is by far the best but if intensely stained the envelope cannot be made out. Other stains employed are Gram, Gram-Wiegert and Kuhnë.

The organism is easily seen however without staining in fresh preparations taken from a recent lesion.

CULTURAL CHARACTERS. It is said that the organism can be cultivated in the laboratory but its growth is very slow; an appearance of growth may occur in ten days but more commonly the time required is much longer, and may extend even to months.

The incubation period of the disease is long, seldom being less than two months, often three and in extreme cases, six.

COMMUNICABILITY. The disease is said by some authors to be easily inoculable from animal to animal artificially, and it may develop in from three weeks to as many months. This somewhat long period is due to the slow development of the organism and the combativeness of leucocytes. Infection generally results through wounds such as may occur from barbed wire; the bite of ticks may also supply a starting point of infection. In natural conditions the disease is propagated also by means of harness and stable utensils, and flies are undoubtedly often concerned mechanically in the transmission of the disease. According to some observers infection also occurs through the soil and it may be possible that the organism is capable of maintaining a separate saprophytic existence outside the animal body. This however, is not definitely known.

SEMIOLOGY. The constitutional symptoms accompanying the disease are not very marked, or may be altogether absent. There is usually only a very slight fever, the temperature seldom exceeding 102° F. The appetite is not impaired except in advanced cases, and there is not the same tendency to lose condition as in farcy, though, in the later stages the animal becomes thin.

The lesions are generally confined to the skin; very exceptionally the mucous membranes are affected. Nocard says the lesions occur most often on the hind legs, withers, back, shoulders, the sides of the neck, and less often on the head. The experience

of the writer however, in the West Indies is that lesions are more commonly to be seen on the fore legs than on the hind legs. If infection results in an existing wound, cicatrisation is arrested, granulations, profuse but pale occur in the wound and a thin serous pus which may be whitish, exudes. The wound extends slowly in all directions and an ulcer with but little tendency to heal results ; after a variable time, from a week up to months the lymphatic vessels show as cords. In other cases even up to six months after healing, a hard but circumscribed tumour forms slowly. This may reach the size of a pigeon's egg, and then burst and discharge a pus either thick and well formed, or yellow and grumous. The cavity of the ulcer fills up with fleshy buds and shows no tendency to heal, and an inflammation of the adjacent lymphatics is apparent in all directions, but is most acute towards the nearest lymphatic gland. Buds form on the cords thus produced and later burst but not often in the order of formation, those nearest the lymphatic glands usually being first. The wound may still contain profuse granulations which bleed on touch ; the edges becoming inverted, each is the opening of a sinus which discharges a yellow, oily, pus sometimes containing fibrinous clots. Some adjoining buds may unite and the skin over the suppurating lymphatics necroses leaving long suppurating open sores. Healing is slow and difficult, and new buds meanwhile form ; the subcutaneous tissue may be invaded by a diffuse reticular lymphangitis which may be confined near a joint or extend over a whole limb. This is at first hot and painful to the touch ; later, buds and cords may be seen and multiple abcesses may form or extensive diffuse suppurations may result. The swelling disappears slowly leaving a thickening of the skin which may be permanent. Healing may take place in a month but more often six months are required and relapses are common. In the absence of treatment the animal may die from exhaustion, or in some cases specific lung lesions may be the cause of death. Ulcerations of the nasal mucous membrane are in rare cases met with, which are nearly always bilateral and may in extreme cases invade the pharynx, larynx, and trachea and even the larger bronchi, and a discharge from the nose, first mucoid and then streaked with blood and muco-purulent may occur.

DIAGNOSIS. Except when the case is retrogressive and the ulcers are old, diagnosis is easy, as except in such lesions the cryptocci are always present, usually in large numbers and cannot be mistaken for any other organism. The pus should be examined microscopically both stained and unstained, the latter either dry or wet. If the smear be thin the double outline of the organism is best seen dry. The size and shape of the organism are such as to render it impossible to confuse it with any other Occasionally yeast cells may be encountered and these are much more confusing though they are usually smaller and rounder than the cryptocci and their envelope is not so prominent. Differentiation from true farcy may be accomplished by means of the mallein test. In the absence of the mallein reaction and the microscope it is not possible to make more than a probable diagnosis between farcy and Epizootic lymphangitis on clinical evidence alone.

Fatality. In all cases the fatality is 10 per cent. or more.

Prognosis. It may be said that the disease is always serious because of its long duration and the possibility of complications; it is held however that if taken in the early stages it is generally curable. Lesions about the region of the loins and neck are the least dangerous; those on the limbs more so. The limbs further may have a resultant thickening and induration which may interfere with the animals usefulness and depreciate its value.

Treatment. The aim of treatment should be the destruction of the virus. In an early case this is easy; the affected tissues can be curetted and cauterized by the hot iron. If cords are forming the position is more serious. If only one cord be formed it is advised that it should be laid open and extirpated. If the cord be extensive or the lymphangitis diffuse, the application of a strong blister may cause encystment or even resolution of the cord. The suppurating buds may be opened and cauterized and caustic injections should be freely used. Perhaps the best of these are zinc chloride, iodine, and bichloride of mercury; actual cautery however probably produces the best results. If the eye becomes affected the nodule may be cut out and cauterized with nitrate of silver or dressed twice daily with a preparation of red precipitate ointment. Some considerable success has lately been attained by the use of neosalvarsan injected intravenously, but this treatment is too expensive to prove of every-day service in the treatment of this disease.

It is worthy of note that a spontaneous cure may be effected by the removal of the affected animals to an elevation of 7,500 feet. This practice is adopted in some parts of India but is of course impossible in the smaller islands of the West Indies.

Prophylaxis. The prevention of the disease may be effected by thorough and rigorous isolation of affected animals, by disinfection of the stables, harness and the products of the disease. The more vigorous preventive method of slaughtering all affected animals is almost too drastic to be conveniently adopted. This was nevertheless the means employed by the military authorities in the case of those animals affected with the disease which arrived in England from South Africa at the termination of the war.

It is of the utmost importance to prevent contamination of wounds by the virus of this disease. Infection may be carried mechanically from an infected ulcer by flies, stable utensils, bandages, or dressings to a non-infected wound on a healthy animal. The organism is very resistant to antiseptics and is not killed by 5 per cent. carbolic acid. A solution of bichloride of mercury of a strength of one in two hundred and fifty may be usefully employed with caution as an occasional dressing for wounds and ulcers and for disinfecting contaminated stalls and appliances. It should further be a precaution that an attendant upon affected animals should not attend to healthy animals.

Autopsy. The post mortem appearances of this disease are, as is to be expected, almost confined to the skin and to the lymphatic vessels, which are inflamed, with thick walls and the lining membranes are hyperaemic and granulous; some of the

lymphatic vessels are blocked, others contain a whitish fluid pus or fibrous fluid. The lymphatic glands are enlarged, infiltrated and yellow red in colour and may show suppurating centres and in older cases hard nodules When the inflammation is diffuse the skin and subcutaneous tissues are thickened in some cases to as much as 2 inches or more and are so dense and fibrous that muscles and tendons may be altered by pressure. The lungs and other viscera are seldom affected; pustules however may occasionally be seen in the lungs either isolated or confluent. In extreme cases a large surface of skin may be destroyed, cartilages may become ulcerated and bones necrosed. Ulcerative changes may extend to the larynx, trachea and larger bronchi.

Legislation exists in Great Britain for the control of this disease under the powers of Diseases of Animals Acts, 1894-1903-- Epizootic lymphangitis Order of 1904. Similar laws are in force in most of the islands of the West Indies but their provisions are not rigidly enforced.

In Natal all clinical cases are destroyed, compensation is paid and a certain amount of control is maintained over the in-contact animals. In the West Indies no similar control is exercised.

ON AGRICULTURAL EDUCATION AND ITS ADJUSTMENT TO THE NEEDS OF THE STUDENTS.

BY FRANCIS WATTS, C.M.G., D.Sc., F.I.C.,

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The very varied aspects and the great range of subjects embraced by the designation agricultural education make it difficult to formulate clear views on the subject and tend to some confusion of ideas ; nor are the difficulties lessened if consideration is given to the tropical aspects of agricultural education. In the latter case attention has to be given to a range of conditions, of crops and of climates that may become bewildering.

In much that has been said concerning agricultural education want of precision has resulted from omission to consider carefully what class of pupil is to be trained under each particular scheme and what he is to be trained for : It may, therefore, be worth while to endeavour to obtain a clear idea of the status of certain pupils and their requirements. In what follows regard is mainly given to Agriculture in its tropical aspects, and chiefly as exemplified in certain West Indian colonies.

Beginning with the most elementary grades consideration may be given to the scholars in elementary schools. Both the critics and the well-wishers of this class are often unduly disposed to urge an extremely utilitarian method of training for these

pupils, having in view, perhaps, unconsciously, something in the nature of a technical school and looking for results such as may be expected from technical training. Obviously this seems unfair alike to teacher and scholar, all that can be expected at this stage is an elementary familiarity with the most striking facts of agricultural life in such phases as will be presented to these elementary scholars when they leave school. They may well be taught elementary facts about plant and animal life, about the manner in which seeds germinate and plants grow and the fundamental relationships of plants to the soil and air. They may also be trained in certain simple operations, such as the sowing of seeds, the propagation of plants by cuttings and perhaps such operations as budding and grafting, and these exercises may—and it is very desirable that they should—extend to simple operations conducted in a school garden, where the pupils may learn something concerning the handling of soil, the arrangements necessary for the cultivation of simple crops, probably principally of culinary vegetables, and of the various incidents requiring the attention of the cultivator in order to bring these crops to maturity, such matters as watering and the protection of the crop from insect pests, all of which, if judiciously handled by the teacher, afford rich stores of material of educational value and enable, even in simple minds, an appreciation to be arrived at of the fundamental facts in the life of a peasant.

More than this it does not seem necessary to look for or expect; indeed if it is carefully looked at it will be seen that it really embraces a wide range, having regard to the child mind, and what is more it admits of being carried into effect in practically every agricultural district and so demands no educational revolution or upheaval.

This is, perhaps, as far as it is necessary to go in connexion with the elementary school and as far as is necessary in the case of the average child who is destined to become an agricultural labourer. Should it be desired to afford training of a somewhat more advanced and technical character some institution other than the elementary school must be looked to.

It must be remembered that the numbers who are to receive this more advanced training will be very much smaller than those attending the elementary schools and that the pupils so trained will stand out above the ordinary agricultural labourer and will look for minor positions of trust carrying higher rates of wages than those of agricultural labourers.

A system of training in some institution where work is carried on for other than educational purposes seems best calculated to meet the requirements of this class. The system may approximate to one of apprenticeship, though the use of this term, particularly in some of the West Indian colonies, has connotations rendering it undesirable.

In most colonies there are Botanic Gardens and Agricultural Experiment Stations where there is a considerable amount of routine work, much of which is capable of being done by agricultural pupils drafted from the elementary schools. The work carried on in these institutions necessarily has a close connexion

with the agriculture of the neigbourhood so that pupils can be trained in work that has real association with the local agricultural industries and they may be trained to acquire a fair perception of the needs of these industries. Their training may consist chiefly in carrying out routine operations and in learning to perform these intelligently and dextrously. In order to minimise the danger of these pupils drifting down and being regarded merely as labourers as well as to increase their usefulness, it is necessary that they receive a certain amount of theoretical instruction in addition to their acquiring manual dexterity in agricultural operations. This may be accomplished by giving an hour's class instruction daily, or perhaps preferably, by devoting one day a week to this form of instruction. The instruction so given should be calculated to afford an insight into the reasons underlying the operations of a practical character in which they are engaged.

It is desirable that pupils of this class should receive a small monetary payment by way of subsistence allowance; the amount must be regulated by local conditions, it should increase progressively, say half yearly, and the acquirement of the increment should be contingent on dilligent work and good behaviour.

It is undesirable that these pupils should be boarded and fed at the institution where they are trained, they and their parents or guardians should make arrangements for their living under conditions having the approval of the authorities responsible for their training. These conditions will much more closely approximate to those in which the pupils find themselves on taking up wage-earning work, while the acquiring of ability to look after their own affairs in the matter of food and clothing is training of considerable value, which is lost if the pupils are boarded and fed by the educational authority. Further, valuable training too is acquired in that the pupils gain a knowledge of the manner of governing their conduct out of working hours, they find how to obtain reasonable recreation and acquire a sense of individual responsibility beyond what can be attained under a system of boarding together with its consequent rules and regulations. On leaving the institution where they have been trained in order to take up wage-earning employment, the change in the manner of living is less violent and the individual has useful experience to guide him.

Such a course of training should suffice to produce the higher grades of labourers and the types of head men who find so large a place in tropical agriculture, men who can work with their hands or, in subordinate capacities, supervise the work of others.

This perhaps suffices for the training of the scholars from elementary schools. It is now necessary to consider the facilities to be offered to those who go through the secondary schools. These cases present greater complexity and in consequence require even more careful planning, combined with an effort to see clearly the position of each class of individual in the general economy.

Experience makes it clear that it is the duty and that it is within the capacity of secondary schools of the Grammar School type situated in agricultural districts to afford its pupils instruc-

tion in the general principles of the sciences fundamental to agriculture such as elementary biology, chemistry and physics, in addition to a good sound general education which should include the general subjects that may be classed as English, elementary mathematics, one classic and one modern language. This instruction in science is the least that can be done and it should be insisted on by all who are responsible for educational schemes in agricultural districts. In some cases this will constitute all the special training a youth obtains, he simply drifts into wage-earning employment and picks up his technical training as he goes along. What is to be done in the tropics to improve upon this is a matter presenting some difficulty.

In some colonies it is possible to afford much useful training by using the Botanic and Agricultural Experiment Stations as training ground for youths from the Secondary Schools just as it is possible to use them for training pupils from the elementary schools. In some West Indian colonies where this scheme is in operation the term Cadet is employed to indicate the student from the secondary school, the term Agricultural Pupil being reserved for the boy from the elementary school: it will be found in practice that distinctions such as this have their value.

During the first year of a cadet's training he should remain closely associated with the secondary school and should continue to attend such science classes as may be considered most likely to be useful to him, the remainder of each working day should be occupied in connexion with the practical work of the Botanic and Experiment Stations. The situation of the Botanic and Experiment Stations near populous centres usually minimises the difficulties attendant upon this divided course of work. For the first year of his training, at least, a cadet should be regarded as within the jurisdiction of the School for purposes of discipline.

The kind of training a cadet may receive will depend upon the nature of the work of the Botanic and Agricultural Experiment Stations of any given district and this in turn will be determined by the nature of the agriculture of the surrounding district. This has its advantages, for the cadet will thus find his work and training approximating closely to the requirements of the distict in which he is placed and in which he may probably have to seek employment, and further, this amount of specialization permits of a cadet being able to spend some time in more than one institution and so acquiring, if necessary, a wide range of agricultural experience. The chain of Botanic and Experiment Stations established throughout the West Indies offers unusually good facilities for study and training of which advantage is being taken.

The training of a cadet embraces the acquiring of some acquaintance with the manner in which the routine office work of the institution in which he is placed is conducted. He learns how correspondence is conducted and records are kept and participates in this work. He acquires a knowledge of the various agricultural and horticultural operations carried on at the institution and attains some skill in the practical carrying out of them; as his experience increases he is placed in charging minor operations and gradually advances to the pure vesosioof

labourers and to responsibilities of a higher order; he also takes part in the experiments and investigations which are undertaken by the institution and learns to appreciate their bearing on the agricultural problems of the district, at the same time learning the value of that accuracy and honesty of purpose which is vital to proper work of investigation.

Such training is calculated to produce in the cadet that right attitude of mind which is the aim and end of training and which when engrafted results in the cadet having acquired such habits of thinking, reading and observing that his education is life-long and he becomes a progressive and useful member of the agricultural community. The nature of his training affords him opportunities for remaining closely in touch with the workers of the Botanic and Experiment Stations and with the work and publications of these and kindred institutions whereby a life-long form of education may, and does, result.

The length of time a cadet should remain under training is often determined by personal considerations, but if possible it should extend to two years, and in some cases as explained below, opportunities for extending the training may usefully be given.

It is desirable that the cadet should receive some small sum of money weekly; while this may be regarded rather as a subsistence allowance than wages it has useful effects in more than one direction. it is extremely useful in that it familiarizes the youth with the handling of small sums of money for his personal use, whereby he learns something of the value and limitations of money and it also adds to his self-respect, for there is no doubt that every right-minded lad feels justifiable pride in his first earnings. Besides the granting or withholding of small increments affords his tutors some tangible means of expressing approbation or disapproval as circumstances may demand.

A very useful purpose may be served by arranging that the cadetship of any particular place may be regarded in the light of scholarships awarded by the secondary schools of the district. It is important to maintain the intimate association between the school and the cadetship and to insist on the continuity of the training; a system of cadet scholarships tends to ensure this.

The effort has been made in some institutions, with a certain degree of success, to afford opportunities for more extended practical training to some of the cadets by filling certain minor posts in the instituion by means of cadets who are allowed to hold these posts for limited periods only and who, at the expiration of the specified time, are required to vacate them in order to make room for others. Occasionally a vacancy may occur on the permanent staff to which a cadet may be promoted.

The training of youths in local institutions like the Botanic and Agricultural Experiment Stations is of value to parents in that the expense of the training is likely to be quite moderate and within their means, as frequently the cadet can live with his parents or relatives; it is also of advantage to employers, for the work and progress of the cadets may be kept under observation and promising youths may be chosen to fill vacancies that arise locally.

In all of this, there is little doubt as to the kind of youth to be trained or the nature of the work for which he is being trained. The cadet is taken to be a youth who has had a good Grammar School or Secondary School training which includes some science subjects such as biology, chemistry and physics, which subjects he continues to study, if possible in his old classes, for a year or so during his cadetship: he is being trained in order that he may take up work on an estate or plantation in a position of minor responsibility with the intention of rising to positions of increased responsibility and ultimately of complete management or control as time and circumstance permit.

It is to be observed that the systems of education so far described are in successful operation in various West Indian colonies; in some instances it may be suggested that the work is proceeding so unostentatiously and quietly that the authorities are hardly aware that they are in possession of fairly complete and, perhaps, moderately adequate systems of agricultural education which would be of still more service to the colonies if they received greater official recognition. It is abundantly clear to thoughtful minds that the quiet work of the Departments of Agriculture in the advocating and in some cases providing agricultural education in the West Indies has already had a far reaching effect that will be felt for some time and this perhaps to an extent not generally recognized.

In order to make provision for those engaged in agriculture who have passed the school age and are engaged in practical, wage-earning work the Imperial Department of Agriculture for the West Indies instituted in 1908 a series of Reading Courses and Examinations in practical agriculture. The reading courses that are recommended cover the general ground of planting experience and are calculated to maintain both a scientific and practical economic interest in the work of estates or plantations covering the wide range of tropical crops.

Lectures and courses of instruction are frequently arranged by the officers of Agricultural Departments in order to assist students who are following the Reading Courses and preparing for examination.

The Examinations are divided into three grades, Preliminary, Intermediate and Final with three classes in each grade. Except in the case of the Preliminary it is an essential condition for admission to examination that the candidate has been practically engaged in the form of agriculture for which he submits himself for examination, mere book work or class instruction is held to be insufficient to qualify for admission.*

It may be briefly stated that the three grades of the Imperial Department of Agriculture examinations are made to correspond

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* Interesting information in this connexion may be obtained from the following references in the *Agricultural News*:

Vol. viii. pp. 90, 341, 365, 381.
Vol. ix. pp. 375, 381.
Vol. x. pp. 29, 31, 45.
Vol. xi. pp. 13, 29, 45, 61, 365, 381, 397, 401, 413.
Vol. xii. pp. 13, 29.
Vol. xiii. pp. 13, 29, 45, 61.

to the three grades in practical planting life. The Preliminary Examination is arranged to ensure in its successful candidates the amount of knowledge that may be reasonably expected in a youth leaving a secondary school to undertake the first steps in an agricultural career. The Intermediate implies such knowledge, both in extent and kind as may be reasonably expected of the young man who has had some practical experience in the more or less subordinate posts of overseer or 'book-keeper', as these employees are technically termed in the West Indies, implying a good all-round knowledge of the routine work of an estate. The Final Examination is planned on lines calculated to enquire into the knowledge and capacity of a man capable of being entrusted with the management of an estate, who is capable of looking at agricultural questions in a somewhat broad spirit extending beyond the acquaintance with matters of estate routine. A First Class Final certificate is intended to indicate a good, sound knowledge of estate routine and practice, (which would be indicated by the possession of the Intermediate certificate), coupled with a wide outlook on agricultural affairs with some ability to deal with the more difficult abstract problems of agricultural management, all acquired in connexion with practical (wage-earning) experience.

The Imperial Department of Agriculture has been independently followed with some modifications by the Local Agricultural Departments of some West Indian colonies which hold examinations and issue their own certificates.

The form of education just sketched may suffice for the needs of many who take up agriculture as their life's work. There remains, however, to be considered that higher form of training which may be given in an Agricultural College.

It is to be expected that the training to be given in an Agricultural College will be of a more academic character than that outlined under the Cadet system, but this is not without its dangers, so that it is desirable there should be more rigorous and clear thinking as to the aims and ends of this training than appears commonly to exist. It is to be remembered that agriculture in its daily practice is an art rather than a science, though it makes liberal and increasing use of various sciences. There is therefore a danger in imagining that a knowledge of agriculture to suffice for earning a livelihood may be required by learning the sciences on which agriculture is based. A little thought will show that this is fallacious: this erroneous idea lies at the root of the objection of the working farmer or planter to the college trained youth, and it may be admitted that in not very remote times this objection was well founded, for Agricultural Colleges were, in many instances, deficient in the means of teaching the art of agriculture while equipped to teach its under-lying sciences.

Another point requires careful setting out, namely, that not all who attend Agricultural Colleges contemplate the full practice of agriculture, that is the raising and selling of crops, as their means of livelihood: many students look to the following of limited lines of work as specialists either as agricultural chemists, entomologists, plant pathologists and so forth. It is clear that

these need different training from those who are destined to become the actual practising farmers or planters: in the former case the knowledge of certain sciences is all important, requiring to be coupled with a less perfect proficiency in the arts of agriculture; in the latter the art or arts, of agriculture are all important, the sciences merely accessory.

In order that the Agricultural College may adequately teach, even in a limited degree, the arts of agriculture it is essential that the College shall be associated with something in the nature of a farm or Experiment Station where the actual agricultural operations of the district are carried on. Unless these operations are conducted on a fairly large scale, and indeed in almost any case, the knowledge to be gained will lack fullness and completeness, so that the student of an Agricultural College will benefit by spending some time upon a farm or plantation in addition to his work at the College.

The advantages offered to the student of an Agricultural College over those afforded to the Cadet lie rather in the wider scope of general education than in advantages in learning the art of agriculture, they imply that the agricultural college student has larger resources in the way of time and money which he can afford to spend in acquiring his training. On completing his training it is conceivable that the agricultural student from the College may be less mature than the Cadet, he will, however, have had a wider education and may be expected to be able finally to advance to higher responsibilities than the cadet.

In affording training for the agricultural specialist the Agricultural College may be expected to achieve success; for the requirements of the specialist may, to a large extent, be taught in class-rooms and laboratories. aided by such surroundings in the way of trial plots or Experimental Stations as may be expected at a College. But even in this work it is essential to have access to agricultural matters in their broad, practical aspects. for it will be necessary to study the practical bearing of the various scientific matters in which expert knowledge is acquired and to which it is to be applied.

It is clear then that Agricultural Colleges, in order to be successful and to discharge their varied functions in the way of educating for subsequent broad training the youths who are to become farmers and planters, and in order to afford adequate training for agricultural scientists, must be planned on very broad and generous lines. They must be sufficiently large to warrant the existence of competent and diversified staffs of teachers, each of whom is thoroughly equipped to deal with his special subject and they must be in possession of, or associated with. a considerable area of land on which the staple agricultural industries of the country are carried on on a commercial scale. These points imply that there must be a comparatively large number of students in order to justify the expenditure in providing the equipment for their training and there must also be assured a demand for the services of the varied classes of students turned out by the College.

Having these considerations in view it is evident that it will be inexpedient to attempt to establish Agricultural Colleges in

small communities or in places where communication is in any way restricted ; such institutions must, for success, be placed in prominent centres of thought and agricultural effort.

It would be of immense advantage if an Agricultural College could be associated with an institution devoted to the work of agricultural research : indeed agricultural research would be the vital stimulus of a healthy, active group of men charged with the duties of educating along various lines the students already referred to.

In planning an Agricultural College, therefore, it will be of great service if the fundamental ideas can be so enlarged as to include both for the professional staff as well as for the advanced students the definitely considered duty of research. In the minds of many who seek the aid of scientific experts in agricultural subjects there exists, in a more or less pronounced degree, the idea that knowledge concerning most of the operations and requirements of the farm or plantation is fairly full and complete and that a competent adviser should be able with comparatively little effort to give, at short notice, a satisfactory answer to most enquiries presented to him : it is little realized how scientific knowledge has grown in the last half century and how in this growing knowledge wider vistas of the unknown and unexplored have come into view. Only those who are working and teaching along the lines of the fore front of agricultural knowledge fully recognize how much there is now that demands investigation and experiment for elucidation. An institute of agricultural research appears to such perhaps to be more of a necessity than an Agricultural College, but it is also clear to them and perhaps to the majority that an institute of agricultural research would be the ideal organization on which to engraft agricultural teaching.

A further useful association on the part of an Agricultural College, particulary for purposes of teaching and training, is an intimate connexion with a Department of Agriculture of the kind now to be found in many colonies. The work of a Department of Agriculture brings it into intimate connexion with the agriculture of a district in all that concerns general development and progress as well as in connexion with the work of combating and controlling pests and diseases. By the intimate association of an Agricultural College with an Agricultural Department it will be possible for advanced students to be afforded opportunities of studying real practical problems and of taking part in real live work connected with the subjects of their special study. With such an association it will be possible also on occasion to place particular pieces of work in the hands of advanced students, whereby under adequate guidance they may acquire and exercise responsibility and originality in an extended degree not readily obtainable in the narrower confines of the College

It is unnecessary here to attempt to do more than indicate in the briefest outline the equipment required in an Agricultural College—which one may now think of as including or being based on an Institute of Agricultural Research. Obviously this must include an adequate professional staff capable of teaching and investigating in regard to Chemistry, Physics, Botany, Mycology, Zoölogy, Entomology, Veterinary Science, Agriculture and

Horticulture, and also the work involved in the specific industries coming within the scope of the College, such as, for example, in connexion with tropical agriculture, the cultivation and preparation of such products as sugar, cacao, tea, coffee, spices, rubber, starches, fibres, fruit and a host of others.

In conclusion it may be stringently urged upon all those giving consideration to the providing of agricultural education that they carefully bear in mind the capabilities and needs of the many classes of students ranging from the agricultural labourer to the scientific expert dealing with only a limited range of subjects, and that in putting forward any scheme of agricultural education they should both ask themselves and answer the questions; What is the aim and object of the training offered; what class of person is it designed for; and what kind of life-work (wage-earning work) is he to be expected to undertake when he has received the training proposed?

Further it is essential to distinguish between those who have in their life's work to regard agriculture as an art, as a thing to be done, and those who have to pay regard to the sciences underlying the agricultural arts, and, what is of great importance, to distinguish between those—the majority—who have to acquire familiarity with the arts of agriculture, but who have the opportunity and the desire to extend their education by learning much of the sciences on which these arts are based. without it being incumbent upon them to practice these sciences in their abstract form, and those who are destined to deal with the sciences fundamental to agriculture, but who have only an indirect concern in the agricultural arts themselves. To the former the sciences are accessory and in the nature of true education, to the latter they are fundamental and the ground of their life's work. Clear appreciation of this fundamental distinction will prevent the tendency to offer the budding farmer or planter fragments of science and to lead him to think that a knowledge of these constitutes his training. It will also lead to the practical farmer or planter's understanding and appreciating the scope of the work of the scientific experts, whether chemist, mycologist, entomologist or what not and to his intelligently and appropriately seeking their aid.

It is worth noting, in conclusion, that advantage has been taken by several students for the purposes of post-graduate study of the facilities afforded by the Imperial Department of Agriculture for the West Indies working in association with various local governments and proprietors of factories and plantations. Five University graduates have received assistance in entomological studies. One student followed a two years course of study in sugar production under the direction of the Imperial Commissioner of Agriculture in connexion with a travelling scholarship awarded by the Government of India, and one graduate from Cambridge is following a course of study in practical agriculture.

THE BUDDING OF CACAO.*

BY JOSEPH JONES.

Curator, Botanic Gardens, Dominica.

Since the notes on the grafting of cacao were published in pamphlet form, experiments in the budding of cacao stocks growing in bamboo pots have been made and a certain measure of success has been achieved.

A means of successfully budding cacao has long been desired chiefly on account of certain inconveniences inseparable from grafting by approach, which added to the expense of producing plants though the method itself, apart from the time occupied and field work involved, is with care, easy to carry on and successful in results.

The budding of stocks has several advantages over grafting by approach, chief amongst which are the centralization of the work in nurseries, and the fact that a selected tree capable of yielding several hundred shoots for inarching during a season, would, in the same time, yield thousands of buds, thus rendering the propagation of a given variety much more speedy than is at present possible by inarching.

The stocks used were of the hardy Calabacillo variety, the seeds being sown in boxes and transferred to bamboo pots when a few months old. Once established in the latter and when in good health and growing condition, budding was attempted which resulted in success.

The method which yielded the highest percentage of successes was the well-known system of patch-budding.

In this form of budding a portion of the bark is removed from the stock and a similar piece with an eye is carefully fitted in its place. When in position, the bud is tied with Raffia and then wrapped with budding tape in order to protect the scion and to exclude air and moisture. In about ten days the bud may be examined, and if signs of union are observed, the tying may be cut or loosened, and the tape again wrapped loosely around the stem as a protection for a few days longer until the bud can be exposed. With careful treatment growth should soon commence. When the young shoots have attained a length of from 6 to 8 inches and become hardened, the upper part of the stock may be removed.

In case of cacao it would not appear desirable to turn down the head of the stock at time of budding.

Experiments with the ordinary shield or inverted T budding, a method extensively used for propagating citrus plants, have yielded poor results. It is unlikely that this system will be successful to any degree in the case of cacao. Patch budding or some modification of this method would appear likely to yield the best results.

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*Reprinted from the Annual Report on the Agricultural Department, Dominica, 1913-14.

It is important to note that if success be achieved great care is needed at every stage of operation.

To accomplish successfully the budding of cacao in bamboo pots is, in the present state of knowledge of this subject, somewhat difficult. Much remains to be learned about this matter by further observation and experiment. It is hoped that the initial work carried out will lead to definite experiments being conducted on a considerable scale and under suitable conditions which will result in this work being carried out ultimately with the same ease and certainty that attends the budding of citrus stocks.

For success, good health and good growing condition of the stock is essential in order that the bark will lift readily from the stem. To obtain these conditions is somewhat difficult in places in which the bamboo joint is used for growing young plants. Though the bamboo joint is largely used in nursery work in the tropics, its small area results in restricting the roots, causing a pot bound condition, which arrests the growth of the plants. Possibly a system of first potting the seedlings stocks in small bamboos and afterwards transferring them to the largest size obtainable would be helpful in maintaining a vigorous growing condition; or the more general employment of baskets or clay pots when the latter are available at a cheap rate, would probably give the desired result.

Experiments are also required to test the effect of growing stocks in beds without any restriction of the root area as in pots. If budding on stocks grown under these conditions proved easy, it remains to be seen whether the plants when strong could be successfully lifted for sale direct to planters, or for transfer to pots or baskets for sale.

Again the adoption of a method of keeping the stocks at the time of budding in frames, the pots being plunged in material with a temperature several degrees above the normal, might be tried with a view of forcing an active condition of sap. Also the action of certain manures in creating a good growing condition preparatory to budding might be experimented with.

Experiments are needed in regard to buds. Should these be taken from a branch which is resting or from one which is making a flush of growth? Should they be taken from well-ripened wood or from the newer growth? The Dominica experiments tend to show that well-ripened buds from a resting branch give the best results.

Much investigation is necessary into their various methods of budding, in the preparation of stocks and in care of plants after successful budding: also in regard to the best season of the year to carry on the work.

So many are the points which require elucidation that it has led to a suggestion being made to employ an expert propagator for the sole purpose of thoroughly investigating these matters in order to indicate clearly the best lines to follow in the work of propagating cacao asexually.

The choice of stock for grafting upon, despite various experiments, remains as limited as before, and is practically confined to the Calabacillo, the hardiest variety of *Theobroma Cacac.* It

Grafting Cacao by approach. (Dominica).

was suggested that perhaps some other species of Theobroma might prove suitable for the work, but up to the present efforts to graft the commercial cacaos upon stocks of *T. bicolor* and *T. Angustifolia* have failed. Nevertheless efforts should be continued to collect and bring together the known species of Theobroma in order to follow this line of experimentation.

As is well known, the leading varieties of *Theobroma Cacao* are known respectively as Criollo, Forastero and Calabacillo. The first named is a delicate kind which yields high grade produce. It needs the best conditions for successful cultivation. The Forastero variety is a good all-round type, fairly hardy, a good yielder of medium grade cacao, and largely cultivated throughout the West Indies. The Calabacillo is the hardiest and yields a low grade produce. Between the main varieties there are many sub-varieties, the result, it is supposed, of natural crossing in plantations.

At present the best stock obtainable is the Calabacillo. Though a hardier stock is still desirable there is no doubt that areas of selected cacao growing upon Calabacillo stocks would represent an enormous advance from a cultural point of view over the mixture of seedlings on their own roots such as are grown to-day in the West Indies.

Owing to the crossing of varieties it is somewhat difficult to find the pure strain of Calabacillo cacao. Should grafting be taken up this matter of obtaining a large and reliable supply of a hardy stock will require very careful thought and experiment.

In looking for scions for propagation at present it is only possible to obtain them from those trees which the grower has had under observation for years, and which have given uniformly good results either in yield combined with good general health, or in the production of high grade seeds. Should the use of asexually propagated plants increase rapidly, it may be expected that the hybridist will undertake the crossing of good forms with a view to the production of the best varieties which, after being proved in the field, will be propagated on a large scale for sale to cultivators. In other words, it may be expected that the growing of cacao in the future will proceed along the lines found so successful in the development of orchard cultivation in temperate climates

The art of budding and grafting, soundly applied, must lead to improvement, because such procedure naturally results in the rejection of inferior kinds. Every variety asexually propagated, whether for its fruit or for its flower, is worth the effort on account of the possession of some quality specially desired. Apart from such advantages as early fruiting, even quality of produce within given areas, higher returns per acre, and ability to resist disease better, it may be laid down as a principle that propagation by these means leads to the cultivation of selected varieties and consequently results in the elimination of unsuitable seedling types.

The experiments conducted in grafting and budding cacao have led to many discussions and expression of opinion both verbal and written. One of the earliest and widely expressed objections advanced against the application of these methods was that the continued asexual propagation would tend to

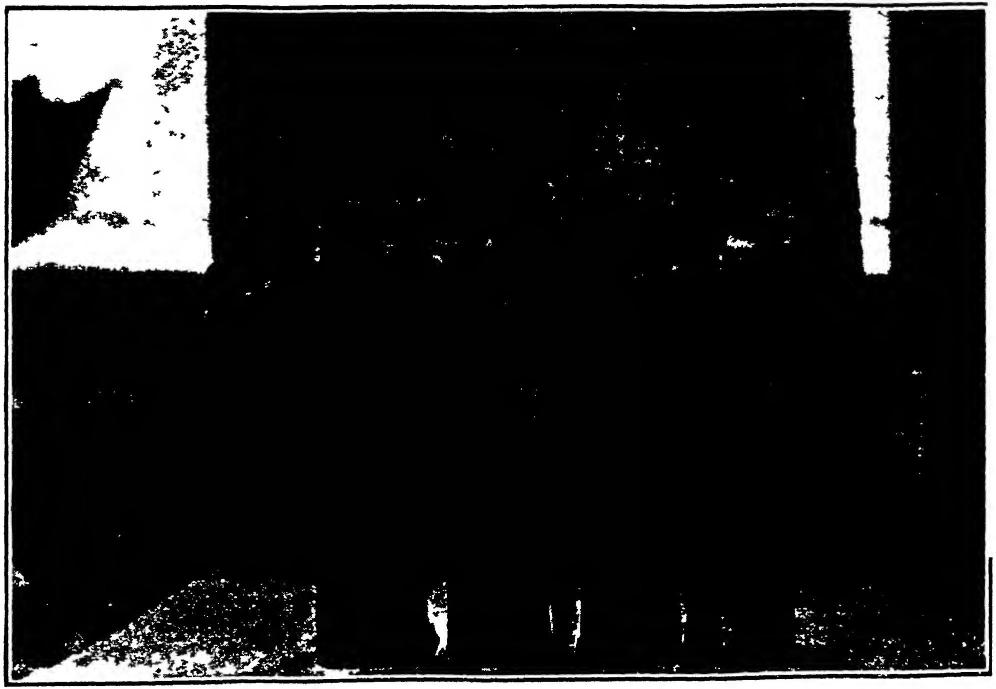
reduce the size and numbers of the seed until nothing but empty shells or pods would result. Enquiry showed that those responsible for the above statement were under the impression that the seedless variety of orange, now so largely grown, was the result of the act of budding repeated over a long period. When the history of the Washington Navel orange was stated, and it was made clear that the seedless orange would have been lost to cultivators but for propagation by budding, by which method it has been fixed and perpetuated, no further criticism was attempted on these lines.

There appears to be no sound basis for assuming that budding or grafting when applied to cacao would result in decreasing the size or number of the seeds. Certain kinds of nuts which have been propagated by these means over long periods have shown no decrease in size or bearing powers nor is such result anticipated.

Fears have been also expressed that asexual propagation of cacao would lead to one type of cacao being cultivated over large areas, which variety might be liable to total destruction by some specific disease sweeping through the plantations It is not anticipated that the application of budding or grafting would bring about the extended propagation of a single variety to the exclusion of others, but rather the reverse. In the case of apples, pears and other fruits, which have been propagated asexually for centuries, there is no case of a single type predominating. Further it is highly improbable that a single variety of cacao would be found which would prove pre-eminent in useful qualities and also suitable for cultivation under the varying climatic conditions of cacao-growing areas throughout the Tropics. What is found in practice is that certain varieties prove to be suitable to the conditions of soil and climate of certain districts within which limited area they may be the leading kinds cultivated.

In support of this statement, orange cultivation may be instanced. The variety most favoured and grown during recent years is the well-known Washington Navel. Its cultivation on an extensive scale in several countries has led to no cultural disaster, neither has the preference accorded to it prevented many other varieties from being grown, the fruits of which have been found to be suited to the markets and desirable on account of some special quality; nor has it prevented experiments being continued by experts in hybridizing with a view of raising new and improved varieties of oranges, which in due course are propagated by budding for sale to cultivators.

The view has been advanced that for the present it would be better to depend on seedlings and to endeavour to obtain hardy and prolific types by rigid seed selection, to be followed by removal of inferior plants from the field as soon as their nature was shown. There is no doubt that the first named suggestion has been in the past and is still being practised by careful planters, but the second one does not appear sound or practicable. The cultivator's argument against such a course would be to the effect that it is a better cultural and paying proposition to have



Budded Cacao (Dominica)

an equally grown field with a proportion of inferior bearing trees rather than make the cultivation unequal when at the age of eight or ten years by removing even a small percentage of inferior seedling trees. Again the supplies recommended being seedlings, the results, owing to variation, might again be unequal, thus necessitating, after another period of time, further efforts in removals and replanting.

Contrast the above recommendations with the use of grafted trees. In this case the variety and its class of produce is known before hand; there need be no removal of trees after years of growth, no loss of lime, no vacant places in the cultivation with the attendent drawbacks of letting in the sunlight and wind at a time when the land should be covered by the trees.

The question has also been asked if in the breeding of new types of cacao for the purpose of being fixed and propagated by grafting, whether high quality of produce, productivity, or power to resist disease should be aimed at. If grafting is taken up by planters, these matters would adjust themselves. In Dominica where a high grade of cacao cannot be produced on a considerable scale, it may be expected that attempts would be made to find and cultivate hardy and prolific varieties while in countries which possess a soil and climate highly favourable, one would expect to find under cultivation the very best grades of cacao. At present it is not to be expected that the qualities of hardiness, productivity and high grade of produce will be found combined in any single variety.

With regard to plantations on which the available areas are already fully planted, advice has been tendered by some that grafted cacao need not be considered in filling vacancies caused by deaths due to disease, etc., it being recommended to continue the use of seedling kinds.

When vacancies occur in closely planted areas it is often better not to attempt to fill the spaces but rather to leave them to be covered in by the adjoining trees which benefit by the additional room. Where there is sufficient space for a plant to thrive, it is surely better to place out a known variety than to leave matters largely to chance by planting seedlings.

A point on which information is needed in this connexion is the percentage of losses of trees on established plantations over a period of years. No such information appears to be obtainable, or indeed to have been recorded. On the best lands and in favoured situations there may be but little loss over long periods, but taking average conditions there is no doubt that plantations after a certain age, owing to deaths from disease and other causes, are being renewed at a more rapid rate than is generally supposed. The average profitable lifetime of the cacao tree does not appear to be known, but probably it does not exceed a period of from thirty to thirty-five years.

Consequently it would appear desirable in filling vacancies amongst established cultivation to use grafted plants. By careful selection varieties can be obtained which will give a return above the average yield of seedlings. Therefore the cumulative effect would be in the direction of increasing the yield per acre, an end desired by all planters.

It is only by planting tried varieties, and by a skilful system of manuring soil management and sanitation that the highest possible returns per acre will be attained and maintained.

If the output of cacao in the West Indies is to be maintained as at present, a certain amount of new planting must be done each year in order to balance the deterioration which is going on amongst old cultivations. If the industry is to continue to expand, considerable additions, to the planted area will have to be made annually. In opening new fields, efforts should be made to plant a proportion with selected grafted varieties in order that observant practical planters can compare the results with seedling cacao growing under similar conditions and under the same management. It is not to be expected that large areas will be planted with grafted trees immediately. The adoption of new methods in planting practice can only be gradual.

To accomplish successfully the initial stages, considerable effort, additional expense and greater care will be required than in the employment of seedlings. There is no reason to doubt that such efforts would be as certainly repaid as in the case of orange and other fruit industries in which budded or grafted plants are wholly employed.

THE ANALYSIS OF CITRATE OF LIME AND CONCENTRATED LIME JUICE.

In view of the uncertainty that has long existed with regard to the methods employed for commercial purposes for the valuation of concentrated lime-juice and citrate of lime the publication of the report of the committee on the study of methods for determining citric acid in citrate of lime and concentrated lemon juice is most welcome. This report appears as a Bulletin of the Ministry of Agriculture, Rome, Vol. 1. Series A. No. 1. dated Rome, January 3, 1914.

The recommendations consist of directing the employment of the well-known method of Warington for the determination citric acid and the employment of the factor 210 as the equivalent of the molecule of citric acid.

The Board of Agriculture, Industrial and Commercial Instruction, called under Art. 48 of the rules for applying the Camera Agrumaria Law, No 404 of 4th July 1908, to give their opinion as to the method to be adopted for determining citric Acid in citrate of lime, thought it opportune to confide the necessary research to a Committee of technical experts, which was composed of the following Professors: —

> Emanuele Patern of the Royal University, Rome; Angelo Menozzi of the Royal High School of Agriculture. Milan; Vittorio Villavecchia of the Customs Chief Laboratory; Gaspare Ampola; Director of the Royal Station of Agricultural Chemistry, Rome; Leobaldo Danesi, Chief Inspector of the Ministry of Agriculture, Industry and Commerce.

The Committee at their first meeting examined the three methods that the Camera Agrumaria had indicated as being preferred by the trade :—viz : those proposed respectively by :—

Dr. Patane
Dr. Spica
Messrs. Ogston & Moore

The method practised by the English chemists, Ogston and Moore in their private laboratory, has always been kept secret, and was on this occasion reservedly communicated to the Committee who, however, at once recognized that it is essentially that of Warington, published in 1875 in the *Journal of the Chemical Society*, Vol. XXVIII, page 934 for the analysis of Citric Acid in the concentrated and crude lemon juices, and which later was adopted by Allen (Commercial Organic Analysis, London, Churchill 1898, Vol. I, pp. 539) for determining citric acid in citrates of lime when they are not sufficiently pure to apply the direct incineration test.

From a study the Committee made of the analytical results transmitted by the Camera Agrumaria and obtained by the above three methods of Patane, Spica and Ogston & Moore, or Warington, it results that those by the last named method are constantly lower than those obtained by the other two.

The three laboratories of the Customs, of the Royal High School of Agriculture, and of the Station for Agricultural Chemistry in Rome, were commissioned to carry out a comparative study for determining the citric acid contents of citrates following the three methods indicated.

The Customs laboratory prepared samples, making up eight, using part of their own stock, and drawing partly from the copious material furnished by the Camera Agrumaria.

The results of the studies of the three laboratories, as shown in the relative reports I, II, and III indicate that :—

1. Ogston and Moore's, Warington's method, though long, has the advantage of greater constancy of results and of considerable independence of the personal equation of the analyst. The method, especially if it is limited to the findings of only two precipitates, does perhaps not give the exact and real determination of the citric acid, but, the question being more than anything one of comparative data, the constancy allows of their being taken as a reliable basis for the commercial valuation of the goods.

2. Patane's method is exact enough, but is long in execution and requires minute care, and is subject to larger variations in the percentage of citric acid found by different analysts in different laboratories.

3. Spica's method although presenting some slight working advantage over the preceding ones, may give fallacious results in the case of sophisticated goods.

For these reasons the Committee decided that Ogston & Moore's or Warington method is preferable, and therefore gave their particular attention to it. Further investigations were decided upon, and the Customs Laboratory requested to prepare fresh samples of citrate.

There were eleven samples in all, some provided by the Camera Agrumaria and others obtained by judiciously mixing different quantities of citrate of lime, of known strength, furnished by the Kalbaum factory, with well judged quantities of foreign matter.

The test made by the laboratories of these samples, have proved that Ogston and Moore's method or rather, that of Warington, by precipitation, executed as described below, besides presenting the advantages already mentioned over the other two, can also give very precise results.

The Committee are therefore unanimously of opinion that citrate of lime and concentrated lemon juice should be analysed by the following method :—

Analysis of Citrate of Lime

Before proceeding to determine the quantity of citric acid, a summary qualitative analysis is necessary to detect the presence of foreign matter, especially of tartaric acid which considerably influences analytical results.

From a well mixed, ground and sifted sample of citrate, take 10 grammes and place in a 250 c.c. graduated flask. Add 21·5 c.c. of hydrochloric acid, sp g. 1·1 and about 50 c.c. of distilled water; boil gently to expel carbon dioxide completely.

After cooling, fill the flask to the mark with distilled water, and pass the contents through a dry filter. Take 50 c.c. of the filtrate with a pipette, corresponding to 2 grs. of citrate of lime, and neutralise exactly with caustic soda, about twice normal and free from carbonate, using phenol-phthalein as indicator. Add 2 c.c. of neutral solution of calcium chloride about 40 per cent. and finally render the liquid slightly acid with a few drops, four to six, of semi-normal hydrochloric acid.

Put this liquid into a hard glass beaker, immerse in a bath of boiling salt water for half an hour, filter while hot through a rapid filter, washing the citrate of lime precipitate on to it with a jet of boiling water, seeking to detach as far as possible that which adheres to the sides of the beaker; continue washing the precipitate collected in the filter, always with boiling water, being careful to employ in all, not more than 150 cc. of water.

Place the filter and precipitate No. 1, thus washed, to dry in a water oven. Neutralise the filtrate with a few drops of dilute ammonia 1·6, and concentrate in the same beaker wherein the first precipitation was made. When reduced in volume to about 30 or 40 c.c. transfer the liquid to a smaller beaker, 50 c.c. add another drop of ammonia and concentrate to 15 c.c. Collect the precipitate on a small filter, washing rapidly with small quantities of boiling water.

Precipitate No 2 with its filter is put to dry and the filtrate treated as before with a few drops of dilute ammonia and again concentrated to 10 c.c.

Precipitate No. 3 is collected on a little filter and washed with extremely small quantities of boiling water and also dried in the water-oven.

The three precipitates, well dried, are now burned together with their filters in one platinum capsule, and afterwards the capsule with the ash is kept for half an hour in a muffle at red heat.

Finally, treat the ash by pouring 50 c.c. of seminormal hydrochloric acid little by little into the capsule and washing it from this into a flask. Boil cautiously to completely dissolve the ash and let cool.

Titrate the excess of acid with caustic soda, quarter normal, using phenol-phthalein as indicator.

From this, the quantity of citrate acid can be calculated, knowing that every c.c. of N/4 solution is equivalent to 0·0175 grm. of crystallized citric acid or, 0·0875 per cent of the sample analysed.

Analysis of Concentrated Lemon Juice.

Weigh out 15 to 20 c.c. of lemon juice, not concentrated, or about 3 c.c. of concentrated lemon juice and neutralise exactly with pure caustic soda of about normal strength.

Dilute to about 50 c.c. and add 20 c c. of pure calcium chloride solution about 40 per cent. Heat for half an hour in salt-water bath and afterwards proceed precisely as for citrate of lime, making three precipitates.

The Committee, considering that all analyses however well described must be made by operators of long experience in order to give sure results and to be quickly executed, recommend that the Camera Agrumaria install a Laboratory of their own for analysing citrate of lime and concentrated lemon juice, with a well selected staff of their own.

THE COMMITTEE.

E. Paterno

A. Menozzi

G. Ampola

L. Danesi

V. Villavecchia

Secretary.
Pini.

Rome, August 9, 1913.

Translation of Extract from Letter Written to the Camera Agrumaria on the Report of the Commissioner of Analytical Methods.

We find that our method, employed here for many years past, is accurately described in this report and we have therefore hardly any comment to make and there will be no difficulty in the way of the regular carrying out of the analyses as in the past.

The evaporation of the filtrate from the second precipitate was mentioned in our description of the method communicated to the Commission, with the remark however, that when the first

operations are properly carried out, one does not usually find an appreciable third precipitate.

We do not usually carry the concentration below 15 c.cm. but according to our experience it is only in exceptional cases that a concentration to 10 c.cms. causes any difference in the result, and this in the less pure citrates when some other acid may be precipitated and the separation of the citric acid made more imperfect.

As to concentrated juice, there would be some criticism to make but the point is of less importance owing to the small quantity of this material now produced..................................

The trade custom is to base the value on the simple acidity of the juice calculated on the basis of the molecular weight 201. The proposed determination of real citric acid by precipitation is certainly more scientific and we would have no difficulty in using it when requested, but the other method is usually accepted in the trade.

In making the precipitation, the concentration should not be carried below 20 c.cm, owing to the greater proportion of impurities present in the juice.

Yours, etc.,

G. H. Ogston & Moore.

SPECIFIC GRAVITIES OF CANE SUGAR SOLUTIONS AT 30° C. (DOUGLAS).

At the West Indian Agricultural Conferences of 1901 and 1902, attempts were made through the agency of a Chemical Committee, to unify the methods employed in the various departmental laboratories in the work dealing with experiments with sugar-cane ; amongst other matters the decision was taken that in making reference to the Imperial gallon, a measure commonly used in connexion with sugar work both in experiments and in factories, it is desirable to state the equivalents of the gallon in terms corresponding to tropical temperatures. For this purpose it was agreed that reference should be made to the Imperial gallon, of 277·27 cubic inches at temperatures of 30° C. or 86° F.

In order that effect might be given to this it became necessary to recalculate the specific gravity tables commonly used in sugar laboratories. This work was undertaken by Mr. William Douglas, F.I.C., F.C.S., who furnished for the use of the laboratories working in association with the Imperial Department of Agriculture a memorandum and tables : these have been largely employed in West Indian laboratories, but being issued in separate form are not easily accessible and run some risk of being lost. It is thought that the publication of this information will serve a useful purpose and the approval of Mr. Douglas to this course has been obtained.

THE SPECIFIC GRAVITY OF SUGAR SOLUTIONS.

By WILLIAM DOUGLAS, F.I.C., F.C.S.

For the comparison of analyses of sugar juices and syrups, manufacturers and others make use of the ratio

$$\frac{100 \text{ sugar}}{\text{Total Solids in Solution}} = \text{Quotient of Purity.}$$

The direct determination of the total solid matter in solution, entails a series of tedious operations which require much time for their execution, and as the results are required chiefly for comparative purposes, it has become customary, to replace this determination by that of Apparent Total Solids or the Solid Matter present in a pure sugar solution of the same specific gravity as the solution analysed. The ratio found being termed the 'Apparent Quotient of Purity.'

In order that the apparent Quotient of Purity as determined by different observers, may be capable of comparison, it is essential that the same table of concordance between Specific Gravity and Sugar per cent. should be employed by all.

In temperate climates, there is little difficulty on this point· the standard table of Mategezek Scheibler & Stammer, which gives the Specific Gravity (17·5 S 17·5) corresponding to sugar per cent., based on Gerlach's determination, is to be found in most books on sugar. The case is different in tropical countries where analyses are conducted at temperatures near 30 C., and the table of Specific Gravities (17·5 S. 17·5) is no longer applicable.

It is often assumed that the expansion of sugar solutions and water does not differ appreciably through ordinary ranges of temperature and concentration, and the Specific Gravity at the temperature of observation, compared with water at the same temperature, is directly employed to find the corresponding sugar per cent., from the table constructed for temperature 17·5 C.

The difference in expansion is however not inconsiderable :—

	Water	20 per cent. Sugar Solution.
0° C.	10,000	10,000
30° C.	10,041	10,074

and is sufficient to affect the Apparent Purity of a cane juice, if calculated in the manner described, by over one degree.

In Germany some years ago the normal temperature for gauging chemical and other apparatus, was changed from 17·5° to 15° C.; on this account the old table of concordance between Sugar per cent. and Specific Gravity (17·5 S. 17·5) was abandoned, and a new table for (15 S. 15) has been calculated by Scheibler from Gerlach's data, and is now in general use.

Gerlach's determinations of the Specific Gravities of Sugar solutions are acknowledged to have a high degree of precision. His tables give the (17·5 S. t) for intervals of 5 per cent. in concentration, 0, 5, 1—75 per cent. and for each 5 degrees of temperature 0°, 5°, 100°, - 100°. C.

The data for 17·5° C. (17·5 S. 17·5) and 30 C. (17·5 S. 30) are

	0%	5%	10%	15%	20%	25%	Sugar
17·5° C	1·0000	1·0197	1·0401	1·0613	1·0832	1·1060	S. G.
30° C	0·9973	1·0166	1·0367	1·0576	1·0794	1·1018	S. G.

	30%	35%	40%	45%	50%	55%	Sugar
17·5° C	1·1296	1·1540	1·1794	1·2056	1·2327	1·2609	S. G.
30° C	1·1253	1·1495	1·1746	1·2005	1·2274	1·2555	S. G.

	60%	65%	70%	75%	Sugar
17·5° C	1·2900	1·3200	1·3512	1·3833	S. G.
30° C	1·2844	1·3142	1·3454	1·3773	S. G.

From Gerlach's data, I have prepared a table which proceeding from 0 per cent. at intervals of 0·1 to 25 per cent. Sugar, and thereafter at intervals of 0·5 to 80 per cent. Sugar, gives the Specific Gravities at 30° C. compared with water at 17·5° C. (17·5 S. 30)* and as it is desirable in industrial operations in British Colonies, that the weight of an Imperial Gallon of a solution should be deducible, by inspection, from its Specific Gravity, for 0 to 25 per cent. I have added a column giving the (62 S. 86) Fah. (uncorrected weights) which is the weight of the Imperial Gallon divided by 10. The next column gives the pounds weight of Total Solid Matter per Imperial Gallon.

The Specific Gravities between the successive five per cents., were found by graphic interpolation.

Gerlach's (17·5 S. 30) for water 0·9973 is slightly higher than the average of the best determinations. Rosetti gives 0·9970. In the calculation of (62 S. 86) I have allowed for this taking the (62 S. 86) for water as 0·9969 which is in agreement with the weight of an Imperial gallon of water at 86° 9·96876 pounds as determined by the British Standards Office. I have compared the Specific Gravities as given in the table with those obtained by pycnometer with pure sugar solutions, at 4 points between 0 per cent. and 25 per cent. and no difference exceeds 0·04 per cent. sugar.

* This part of the table which is as stated an extension of the figures given above is not reproduced. The (62·S. 86) F. values and the equivalent pounds of sugar per gallon only being given. It may be noted that the figures for specific gravity at 30° C (17·5 S·30) differ from those in the above table by the adding of ·0004 for solutions containing from 0 per cent. to 17·7 per cent. of sugar and thence from 17·8 per cent. to 25 per cent. by ·0003, so that the portion of the table now omitted is readily obtained by inspection.

Specific Gravities of Cane Sugar Solutions at 30° C. (Douglas).

Per cent. sugar Brix.	Pounds wt. per gall. 10 / 62 S. 86° F. (in air).	Pounds sugar per Imperial gallon.	Per cent. sugar Brix.	Pounds wt. per gall. 10 / 62 S. 86° F. (in air).	Pounds sugar per Imperial gallon.
0·	0·9969	0·	3·	1·0083	0·302
·1	·9973	·010	·1	1·0087	·313
·2	·9977	·020	·2	1·0091	·323
·3	·9980	·030	·3	1·0095	·333
·4	·9984	·040	·4	1·0099	·343
·5	·9988	·050	·5	1·0103	·354
·6	·9992	·060	·6	1·0106	·364
·7	·9996	·070	·7	1·0110	·374
·8	·9999	·080	·8	1·0114	·384
·9	1·0003	·090	·9	1·0118	·395
1·	1·0007	·100	4·	1·0122	·405
·1	1·0011	·110	·1	1·0126	·415
·2	1·0015	·120	·2	1·0130	·425
·3	1·0018	·130	·3	1·0134	·436
·4	1·0022	·140	·4	1·0138	·446
·5	1·0026	·150	·5	1·0142	·456
·6	1·0030	·160	·6	1·0146	·467
·7	1·0034	·171	·7	1·0150	·477
·8	1·0037	·181	·8	1·0154	·487
·9	1·0041	·191	·9	1·0158	·498
2·	1·0045	·201	5·	1·0162	·508
·1	1·0049	·211	·1	1·0166	·518
·2	1·0053	·221	·2	1·0170	·529
·3	1·0056	·231	·3	1·0174	·539
·4	1·0060	·241	·4	1·0178	·550
·5	1·0064	·252	·5	1·0182	·560
·6	1·0068	·262	·6	1·0186	·570
·7	1·0072	·272	·7	1·0190	·581
·8	1·0075	·282	·8	1·0194	·591
·9	1·0079	·292	·9	1·0198	·602

Specific Gravities of Cane Sugar Solutions at 30° C. (Douglas).

Per cent. sugar Brix.°	Pounds wt. per gal. $\frac{10}{62}$ S. 86° F. (in air).	Pounds sugar per Imperial gallon.	Per cent. sugar Brix.°	Pounds wt. per gal. $\frac{10}{62}$ S. 86° F. (in air.)	Pounds sugar per imperial gallon.
6·	1·0202	0·612	9·	1·0322	0·929
·1	1·0206	·623	·1	1·0326	·940
·2	1·0210	·633	·2	1·0330	·950
·3	1·0214	·643	·3	1·0334	·961
·4	1·0218	·654	·4	1·0338	·972
·5	1·0222	·664	·5	1·0343	·983
·6	1·0226	·675	·6	1·0347	·993
·7	1·0230	·685	·7	1·0351	1·004
·8	1·0234	·696	·8	1·0355	1·015
·9	1·0238	·706	·9	1·0359	1·026
7·	1·0242	·717	10·	1·0363	1·036
·1	1·0246	·727	·1	1·0367	1·047
·2	1·0250	·738	·2	1·0371	1·058
·3	1·0254	·748	·3	1·0375	1·069
·4	1·0258	·759	·4	1·0379	1·079
·5	1·0262	·770	·5	1·0384	1·090
·6	1·0266	·780	·6	1·0388	1·101
·7	1·0270	·791	·7	1·0392	1·112
·8	1·0274	·801	·8	1·0396	1·123
·9	1·0278	·812	·9	1·0400	1·134
8·	1·0282	·823	11·	1·0404	1·144
·1	1·0286	·833	·1	1·0408	1·155
·2	1·0290	·844	·2	1·0412	1·166
·3	1·0294	·854	·3	1·0417	1·177
·4	1·0298	·865	·4	1·0421	1·188
·5	1·0302	·876	·5	1·0425	1·199
·6	1·0306	·886	·6	1·0429	1·210
·7	1·0310	·897	·7	1·0433	1·221
·8	1·0314	·908	·8	1·0438	1·232
·9	1·0318	·918	·9	1·0442	1·243

Specific Gravities of Cane Sugar Solutions at 30° C. (Douglas).

Per cent. sugar Brix.°	Pounds wt. per gal. 10 / 62 S. 86° F. (in air).	Pounds sugar per Imperial gallon.	Per cent. sugar Brix.°	Pounds wt. per gal. 10 / 62 S. 86° F. (in air).	Pounds sugar per Imperial gallon.
12·	1·0446	1·254	15·	1·0572	1·586
·1	1·0450	1·264	·1	1·0576	1·597
·2	1·0454	1·275	·2	1·0580	1·608
·3	1·0459	1·286	·3	1·0585	1·620
·4	1·0463	1·297	·4	1·0589	1·631
·5	1·0467	1·308	·5	1·0593	1·642
·6	1·0471	1·319	·6	1·0597	1·653
·7	1·0475	1·330	·7	1·0691	1·664
·8	1·0480	1·341	·8	1·0606	1·676
·9	1·0484	1·352	·9	1·0610	1·687
13·	1·0488	1·363	16·	1·0614	1·698
·1	1·0492	1·374	·1	1·0618	1·709
·2	1·0496	1·385	·2	1·0623	1·721
·3	1·0501	1·397	·3	1·0627	1·732
·4	1·0505	1·408	·4	1·0632	1·741
·5	1·0509	1·419	·5	1·0636	1·755
·6	1·0513	1·430	·6	1·0640	1·766
·7	1·0517	1·441	·7	1·0645	1·778
·8	1·0522	1·452	·8	1·0649	1·789
·9	1·0526	1·463	·9	1·0654	1·801
14·	1·0530	1·474	17·	1·0658	1·812
·1	1·0534	1·485	·1	1·0662	1·823
·2	1·0538	1·496	·2	1·0667	1·835
·3	1·0543	1·508	·3	1·0671	1·846
·4	1·0547	1·519	·4	1·0676	1·857
·5	1·0551	1·530	·5	1·0680	1·869
·6	1·0555	1·541	·6	1·0684	1·880
·7	1·0559	1·552	·7	1·0689	1·892
·8	1·0564	1·563	·8	1·0694	1·904
·9	1·0568	1·575	·9	1·0699	1·915

Specific Gravities of Cane Sugar Solutions at 30° C. (Douglas).

Per cent. sugar Brix.°	Pounds wt. per gall. 10 / 62 S 86° F. (in air).	Pound sugar per Imperial gallon.	Per cent sugar Brix.°	Pounds wt. per gall. 10 / 62 S. 86° F. (in air).	Pounds sugar per Imperial gallon.
18·	1·0703	1·927	21·	1·0835	2·275
·1	1·0707	1·938	·1	1·0839	2·287
·2	1·0712	1·950	·2	1·0844	2·299
·3	1·0716	1·961	·3	1·0848	2·311
·4	1·0721	1·973	·4	1·0853	2·323
·5	1·0725	1·984	·5	1·0857	2·334
·6	1·7029	1·995	·6	1·0861	2·346
·7	1·0734	2·007	·7	1·0866	2·358
·8	1·0738	2·019	·8	1·0870	2·370
·9	1·7043.	2·030	·9	1·0875	2·382
19·	1·0747	2·042	22·	1·0879	2·393
·1	1·0751	2·053	·1	1·0884	2·405
·2	1·0756	2·065	·2	1·0888	2·417
·3	1·0760	2·077	·3	1·0893	2·429
·4	1·0765	2·088	·4	1·0897	2·441
·5	1·0769	2·100	·5	1·0902	2·453
·6	1·0773	2·112	·6	1·0906	2·465
·7	1·0778	2·123	·7	1·0911	2·477
·8	1·0782	2·135	·8	1·0915	2·489
·9	1·0787	2·147	·9	1·0920	2·501
20·	1·0791	2·158	23·	1·0924	2·512
·1	1·0795	2·170	·1	1·0929	2·524
·2	1·0800	2·182	·2	1·0933	2·536
·3	1·0804	2·193	·3	1·0938	2·548
·4	1·0809	2·205	·4	1·0942	2·560
·5	1·0813	2·217	·5	1·0947	2·572
·6	1·0817	2·228	·6	1·0951	2·584
·7	1·0822	2·240	·7	1·0956	2·596
·8	1·0826	2·252	·8	1·0960	2·608
·9	1·0831	2·263	·9	1·0965	2·620

Specific Gravities of Cane Sugar Solutions at 30° C. (Douglas).

Per cent sugar Brix.	Pounds wt. per gall. / 10 62 S. 86 F. (in air).	Pounds sugar per Imperial gallon.
24·	1·0969	2·632
·1	1·0974	2·645
·2	1·0978	2·657
·3	1·0983	2·669
·4	1·0987	2·681
·5	1·0992	2·693
·6	1·0997	2·705
·7	1·1001	2·717
·8	1·1006	2·729
·9	1·1010	2·741
25·	1·1015	2·754

REPORT ON THE PREVALENCE OF SOME PESTS AND DISEASES IN THE WEST INDIES DURING 1913.

The present report forms a continuation of those previously published, which have covered five periods. The extent of each period and the reference to the volume and page of the *West Indian Bulletin* where these have appeared, are shown below:—

April 1908—June 1910, Vol. XI, p. 73
July 1910—March 1911, Vol. XII, p. 412
April 1911—December 1911, Vol. XII, p. 412
January—December 1912, Vol. XIII, p. 333.

The present report covers the period January-December 1913. The information presented in this report has been forwarded by the Agricultural Officers in the several islands represented.

During the year the Entomologist paid one visit to Dominica to investigate a reported outbreak of an insect pest attacking oranges in that island. This insect is the orange moth, which has appeared in one district in Dominica at intervals for several years past. Only a few specimens have been received at this office, and as none of these have been good enough for study, the insect is still unnamed. A brief account of this insect was given in the *Agricultural News* for November 22, 1913 (Vol. XII, p. 378).

The Mycologist, Mr. F. W. South, B.A., visited Montserrat in January-February 1913, in connexion with the investigation of diseases of limes. Mr. South resigned his post in March, and his successor, Mr. W. Nowell, D.I.C., who assumed the duties of the office in September, did not travel during the remainder of 1913.

CLIMATE

ST. VINCENT. A very wet season.

ST. LUCIA. Unusually dry in December 1913 and January 1914, otherwise normal.

DOMINICA. The climatic conditions during the year 1913 were favourable. Moderate rainfall and absence of gales or continued high winds characterized the period.

ANTIGUA. The season of 1913 was a fairly good one; 43·99 inches of rain fell during the year. The wettest month was that of May during which 10·79 inches fell. This was followed by two dry months; the latter end of the year was fairly good.

ST. KITTS. The rainfall for the year 1913 was 43 63 inches in the Basseterre district and 75·42 in the northern district. In addition to the low rainfall in the former district, the distribution was unsuitable to cane and cotton. In the first five months there was no want of rain, but from June to September the weather conditions were unsuitable for the growing canes, and for the planting of cotton.

NEVIS. The weather, on the whole, was not very favourable, and the early corps suffered very much from drought. Towards the end of the year the weather was somewhat moist, which caused boll-dropping and mildew on cotton.

VIRGIN ISLANDS. Very dry weather, 13·31 inches of rain measured during year.

PART I. -INSECT PESTS.

BY H. A. BALLOU, M.Sc.,

Entomologist on the Staff of the Imperial Department of Agriculture.

SUGAR-CANE.

MOTH BORER (*Diatraea saccharalis*).

GRENADA. Has occurred in all cane districts: no serious damage has been recorded.

ST. VINCENT. Few observations on cane pests. Nothing unusual. No reports of damage out of ordinary.

ST. LUCIA. Present, but not to any serious extent.

ANTIGUA. No serious attack; most common in June.

ST. KITTS. In every field of cane; damage not so apparent as in previous year.

NEVIS. Fairly abundant on all estates.

VIRGIN ISLANDS. Moth borer observed in cane fields. No serious attacks. No appreciable damage considered to have been done.

The moth borer occurs in all districts where sugar-cane is grown but the damage caused by its attacks is generally under-estimated. In periods of severe drought or when canes are left standing long after they are ripe, the excess of injury over the normal condition is appreciated.

WEEVIL BORER (*Sphenophorus sericeus*).

ST. LUCIA. Found in most cane fields; no serious outbreak.

ANTIGUA. Prevalent in all cane fields.

ST. KITTS. Occurred only in rotten canes or canes damaged by wind. No record of its being present over any large area, or doing any particular damage.

This insect is of general occurrence throughout the West Indies.

ROOT BORER.

ST. LUCIA. Present; no serious damage reported.

ST. KITTS. No record of occurrence in large numbers, or doing any great damage. Specimens found on one estate and forwarded to Head Office.

The root borer in St. Lucia is probably the larva of *Diaprepes abbreviatus*; that in St. Kitts, the larva of *Exophthalmus esuriens*.

CANE FLY (*Delphax saccharivora*).

No record of occurrence in any of the islands during the year.

Although this insect has a general distribution throughout these islands, it has not been reported during the five periods covered by this and previous reports.

TERMITES.

ANTIGUA. Fairly common in fields of cane, especially on the borders. Not regarded as a serious pest.

ST. KITTS. The pest, although not doing anything like the damage caused by it in former years was still to be found on the Pond estate. The rotation with cotton seems effectual in ridding the lands of these termites where it was followed up for some years.

Leucotermes tenuis continues to attack canes in the vicinity of its original appearance, and is not known to have spread to other parts of the island.

HARD BACK GRUBS.

ST. LUCIA. Found occasionally.

ANTIGUA. Common during early and latter part of year; especially so in heavy lands in central part of island. It is possible that a fair percentage of the damage for which these pests are blamed is caused by root fungus, and in some cases poor cultivation.

ST. KITTS. *Lachnosterna patruelis*, root trimmer of canes, occasionally found but not doing much damage.

This heading is intended to cover attacks by the grubs of the Melolonthid beetles, i.e., beetles (not weevils) of the hard-back type whose larvae are possessed of three pairs of legs. The Antigua species is *Lachnosterna* sp., that of St. Kitts is *L. patruelis*, while those referred to from St. Lucia are doubtful.

SCALE INSECTS AND MEALY-BUGS.

ANTIGUA. Mealy-bug (*P. calceolariae*) fairly abundant on mature canes. Not regarded as a serious pest.

GRASSHOPPERS.

ST. LUCIA. Grasshoppers quite common; no damage reported.

ANTIGUA. Grasshoppers were responsible for slight damage in few localities.

ST. KITTS. Grasshoppers very plentiful in the early part of the year; they cut down young plants. On some estates

flocks of Guinea birds are kept to destroy grasshoppers with great success.

The common grasshopper in St. Kitts and Antigua is *Schistocerca pallens*: that mentioned as occurring in St. Lucia is probably the same.

COTTON.

COTTON WORM (*Alabama argillacea*).

ST. VINCENT. No attack recorded.

ST. LUCIA. Troublesome—not so severe as in 1912. Only 15 acres of cotton grown in St. Lucia, in Choiseul district.

MONTSERRAT. Cotton worm made its appearance in small numbers about September when first crop of cotton was picked or ripening. Fairly severe attacks were experienced later on the second growth but extensive damage was not done. Cotton worm, on the whole, was not severe.

ANTIGUA. Repeated attacks from June to December. These were very severe during November and December.

ST. KITTS. Very prevalent in latter part of year, and large quantities of Paris green and lime were used to keep the insect in control.

No attack in Anguilla during the year.

NEVIS. Not nearly so severe as in 1912: some places free from attack. In other localities, fairly severe attacks were experienced.

VIRGIN INSLANDS. Isolated attacks during the year. Damage very slight.

In the last report it was stated that the cotton worm did not occur in Grenada, and that St. Vincent had experienced a severe attack. No mention of this pest being in Grenada during 1913 indicates that for a second season that island was free from attack.

In St. Vincent, the cotton worm has again relapsed into the position of insignificance which it has held in nearly every season for the past ten years.

BOLL WORM.

ANTIGUA. Found in most fields during growing season.

The boll worm (*Heliothis obsoleta*) and the corn ear worm, (*Laphygma frugiperna*) both occur throughout the West Indies, but rarely appear as pests of cotton, though often being plentiful in fields of Indian corn.

COTTON STAINERS (*Dysdercus* spp.).

ST. VINCENT. Few at end of season. Season a wet one, and stainers do not seem to like wet weather.

ST. LUCIA. Present, but not serious.

MONTSERRAT. Both *D. andreae* and *D. delauneyi* were present in large numbers in early part of 1913. Cotton planted in February was attacked by them. A very large number of the insects was destroyed by means of traps and kerosene emulsion. As the season wore on the insects became less plentiful, and the first crop of cotton did not suffer much from the attack.

ANTIGUA. Common during latter part of year but in no way as numerous as in 1912.

ST. KITTS. Very prevalent on old, matured cotton bushes, but not much damage was done, as very little cotton is kept for a second picking.

NEVIS. Observed to a great extent in many fields, especially the late ones.

VIRGIN ISLANDS. *D. andreae* prevalent to a great extent. *D. delauneyi* observed, but not as common as *D. andreae.*

SCALE INSECTS

BLACK SCALE (*Saissetia nigra*).

WHITE SCALE (*Hemichionaspis minor*).

ST. VINCENT. Black scale fairly prevalent as usual in the Leeward district.

ST. LUCIA. White scale fairly numerous.

MONTSERRAT. Black scale. This scarcely constitutes a serious pest in Montserrat at present, though a very considerable number of plants was noticed to be infested.

ST. KITTS. Black scale not a pest of cotton in St. Kitts; the plants are not kept long enough for this to develop.

No white scale recorded on cotton in St. Kitts during year.

NEVIS. Both these scales were observed in many fields of old cotton. The black scale was more abundant than in 1912, but many of the insects were parasitized.

VIRGIN ISLANDS. Both black and white scales observed.

LEAF-BLISTER MITE (*Eriophyes gossypii*).

ST. VINCENT. Not a serious pest. Present as usual, more particularly at end of season.

ST. LUCIA. Present; no serious damage.

MONTSERRAT. This pest was not present on the first crop of cotton in sufficient quantity to do serious injury. Sporadic cases of severe attack, noted all through the fields of one estate where care had been taken to remove all old plants previous to planting, are difficult to understand, i.e. single plants were seen to be badly infested, while surrounding plants were practically free. Is it a case of marked susceptibility to the disease or merely a coincidence that these plants were infected by wind or birds?

ANTIGUA. Occurred generally in fields of old cotton. Especially prevalent on growth made after severe caterpillar attacks. Present in fields possessing unsuitable soil conditions, and after spells of drought.

ST. KITTS. This always attacks maturing cotton, but it is not feared as a pest unless it attacks very young cotton.

NEVIS. Occurred to a fairly great extent in all the early fields, and in the late ones toward the end of the crop.

VIRGIN ISLANDS. Very common in all parts of the islands; caused considerable damage in 1913.

FLOWER-BUD MAGGOT (*Contarinia gossypii*).

MONTSERRAT. Not seen or heard of in 1913.

ANTIGUA. First appearance of this in October. Attack rather severe in several fields.

APHIS (*Aphis gossypii*).

ANTIGUA. Sporadic attack in September and October.

NEVIS. Prevalent in a few early fields.

VIRGIN ISLANDS. Appeared in September and October.

LACHNOPUS WEEVIL.

ST. KITTS. Anguilla. Grey weevil (*Lachnopus*) very destructive to young cotton plants, eating off young leaves and causing much damage.

Lachnopus weevils are known to occur in Anguilla, Nevis, Tortola, Antigua, and St. Kitts. The adults attack young cotton plants, feeding on the leaves and buds. The grubs are not known. *Lachnopus valgus* occurs in Anguilla, *L. curvipes* in Tortola, and another species, as yet unidentified, occurs in Antigua. St. Kitts and Nevis.

CACAO.

THRIPS (*Heliothrips rubrocinctus*).

GRENADA. Occurred in most districts; no severe attack reported in 1913.

ST. VINCENT. Further outbreak at one estate was recorded.

ST. LUCIA. No severe attacks reported.

DOMINICA. There was an outbreak of thrips on young cacao trees not well established in Botanic Gardens. They caused the falling off of a large number of leaves. The trees were sprayed and the insects got under control.

BEETLE (*Steirastoma depressum*).

GRENADA. As usual, collecting the grubs has been a part of daily routine on most of the West Coast estates.

SCALE INSECTS AND MEALY-BUGS.

GRENADA. In the drier districts (St. Georges and St. Patricks). mealy-bug attacks have increased in 1913. Spraying has been resorted to in one or two cases. There seems every likelihood of these pests increasing in virulence in the next season or two.

ST. KITTS. Mealy-bugs occurred in young cacao at one estate but as soon as the shade trees were trimmed and more light given them the trees cleared up.

TERMITES.

GRENADA. Termites have done fairly serious damage in certain districts. Several cases have been noted where these insects have tunnelled into healthy wood of the cacao tree. Further observations are being made, and reports will follow.

The species concerned in this is *Calotermes balloui*, which is also recorded as tunnelling into the solid heartwood of a Saman tree in St. Vincent.

LIMES AND OTHER CITRUS.

SCALE INSECTS.

Purple scale (*Lepidosaphes beckii*). White or snow scale (*Chionaspis citri*). Green scale (*Coccus viridis*).

West Indian red scale (*Selenaspidus articulatus*). California red scale (*Chrysomphalus aurantii*).

GRENADA. The sole cultivation in Grenada, the experiment plot at Morne Rouge was healthy. The usual scales, however, are present everywhere on citrus trees. *Sphaerostilbe coccophila* in 1913 did useful work in St. David's and will probably be a more useful control in the near future.

ST. VINCENT. Situation unchanged Scale insects prevalent, especially the green scale, the citrus trees dying.

ST. LUCIA. The purple, snow and green scales are common, generally throughout, the green being most troublesome in fairly moist situations, and the snow and purple scales being more severe in exposed and dry localities. The West Indian red scale comparatively speaking, is scarce.

DOMINICA. Complaints relating to scale insects are not as frequent as in former years; this is possibly due to the more general attention to the question of manuring. Young trees not thoroughly established seem most liable to attacks of scales.

MONTSERRAT. The purple scale did serious damage on certain areas, and young trees, in particular, suffered severely. The green scale was not particularly common, and for this reason black blight was not generally prevalent.

ANTIGUA. Common in all lime fields, attacks much less severe during present season than in previous years. The green and West Indian red scales are decreasing in numbers. White scale apparently not decreasing. Purple scale fairly common. The damage done by wind is often placed to the credit of scale insect attack. This is being realized by some planters.

ST. KITTS. No lime cultivation carried on to any extent. Scale insects are very prevalent wherever lime trees are grown.

NEVIS. The purple and green scales observed in every plantation and almost on every tree (lime or orange) in the island. The white scale is also seen occurring to a fairly great extent.

VIRGIN ISLANDS. Purple and white scales occur.

BARK BORER (*Leptostylus praemorsus*).

ST. LUCIA. Found on one estate, but not serious.

DOMINICA. May be found fairly commonly on estates in the La Soye district, but planters concerned regard it as easy of control. The percentage of trees attacked is very low indeed.

TWIG BORER (*Elaphidion mite*).

ANTIGUA. Isolated instances found. The energetic measure adopted last year for its control possibly accounts for its decrease.

NEVIS. Observed to a fairly great extent in some places.

ORANGE MOTH.

DOMINICA. Quite prevalent on estates in the interior of island. Fully reported on during the year, and was the object of a special investigation by the Entomologist.

SWEET POTATOES.

SCARABEE OR JACOBS (*Cryptorhynchus batatae*).

GRENADA. This occurred in all districts in 1913.

ST. VINCENT. Present, as usual, in most places.

ANTIGUA. No definite instances of the above have been seen during period under review. There has been a decided diminution of this during the last three years.

ST. KITTS. This pest does not seem to do much damage in St. Kitts. There has been no record of its appearance.

NEVIS. Observed to a fairly great extent in some fields, especially in those where the crop was left over.

VIRGIN ISLANDS. The presence of 'Jacobs' was recorded during 1913.

CATERPILLARS (*Protoparce cingulata*).

ST. LUCIA. Fairly common in the Choiseul district.

ANTIGUA. No serious damage done by this pest; common in some fields during latter end of the year.

VIRGIN ISLANDS. Potato worm was noticed during 1913.

THRIPS.

ANTIGUA. Isolated instances of the above found.

RED SPIDER (*Tetranychus telarius*).

ST. LUCIA. A few patches observed but nothing serious.

ANTIGUA. Fairly common on potatoes growing in poor soil or hot situations.

COCO-NUTS.

WEEVIL (*Rhynchophorus palmarum*).

ST. VINCENT. A few trees were reported as being attacked.

WHITE FLY (*Aleyrodicus cocois*).

ST. VINCENT. Not much in evidence.

ST. KITTS. The trees seemed very healthy, but there is no actual cultivation of this crop carried on in St. Kitts.

NEVIS. Not observed.

The fact that the coco-nut white fly was not observed in Nevis is recorded here as being of special interest since a considerable area of coco nuts has been planted in that island during the last seven or eight years. The coco nut white fly occurs at times in abundance in certain islands to the south of Nevis.

SCALE INSECTS.

GRENADA. Universal, but but few severe attacks.

ST. LUCIA. The common scales such as *Aspidiotus destructor*, etc, general throughout, but no serious attacks reported.

ANTIGUA. Common. Especially *Aspidiotus destructor* on older leaves of mature plants and on young trees.

ST. KITTS. Scale insects are to be seen on the fronds but little damage is done.

NEVIS. *Aspidiotus destructor* observed in a coco-nut plantation, and on coco nut trees in other parts of the island. *Vinsonia stellifera* observed in many places, but not doing any damage.

VIRGIN ISLANDS. *Aspidiotus destructor*.

Indian Corn.

CORN EAR WORM (*Laphygma frugiperda*). BOLL WORM (*Heliothis obsoleta*).

CORN EAR WORM.

ST. VINCENT. Quite bad in places.

ST. LUCIA. Common in all patches of corn ; completely destroyed the small lot at Réunion, as it attacked as the drought set in and growth was below normal.

MONTSERRAT. This pest is invariably present on Indian corn in Montserrat. Kerosene emulsion was tried as a remedy but it destroyed the plants.

ANTIGUA. Fairly abundant. Responsible for a fair amount of damage to crops.

ST. KITTS. This pest is very troublesome. especially in dry weather: has occurred all over the island.

NEVIS. Observed in every field to a fairly great extent.

HARD BACK GRUBS.

MONTSERRAT. Hard backs seem to be a very general pest in the adult stage, being found on a variety of plants. No observations have been made for attacks of the grubs.

ANTIGUA. This pest was extremely common in some fields and was possibly responsible for the almost total destruction of corn crops in them. Common during April and May, and during latter end of year.

The reference here given to the hard back grubs in Antigua is to the larva of the Antigua brown hard back, *Lachnosstoma* sp. The Montserrat reference appears to be to the occurrence of the weevil *Exophthalmus esuriens*, the grub of which is now known to be a root borer. This insect is called a hard back in some localities, and this leads to the confusion of entirely different insects.

Ground Nuts.

GREEN BUGS (*Edessa meditabunda*).

ST. VINCENT. Did some damage in certain fields.

LEAF-EATING CATERPILLARS.

ANTIGUA, Found commonly at Skerretts' during latter end of year.

NEVIS. Observed in plot at experiment station.

Onions.

CATERPILLARS.

ANTIGUA. Attacks of this pest were experienced throughout growing season.

NEVIS. Observed in many plots and nursery beds, but not to a great extent.

THRIPS.

ANTIGUA. Found commonly in fields as crop was reaching maturity. Did but little damage.

RUBBER.

SCALE INSECTS.

ST. LUCIA. Present generally, but no serious attack.

ST. KITTS. No cultivation in St. Kitts. The few trees grown on one estate are not so badly affected as in the early stages of growth.

GREEN DRESSINGS.

ST LUCIA Horse beans were destroyed by the acre at Réunion by a caterpillar believed to be the same as that which attacks the sweet potato (*Protoparce cingulata*). From about 7 to 9 a m. each day the plots swarmed with the wild bee (*Polistes annulatus*) feeding upon the caterpillars All the Crotalaria varieties had their seed pods punctured and the seeds destroyed by a small hairy black caterpillar with red marginal stripes. *Tephrosia candida* remained unattacked.

GENERAL REMARKS.

MONTSERRAT. Numerous complaints are received about the damage done by slugs to provision crops on the upper lands of certain estates situated at the bases of the mountains.

ST. KITTS The Jack Spaniard is a very useful enemy against the cotton worm, and in Anguilla it is thought that it has had very much to do with keeping the cotton worm in check, as the Jack Spaniards were seen in large numbers among the cotton plants.

Generally speaking, the year under review has been particularly free from any serious pests to cane or cotton, and no new pest has been found.

NEVIS. The parasite of the cotton worm, which was found to a great extent last year was observed in only one or two places this season, and not to any great extent.

The crops, on the whole, were not attacked to any great extent by any serious pests, and the mild attack by cotton worm in certain localities and its absence in other places, are note-worthy. A fair amount of damage was done to some fields by this pest, but this was due rather to bad management in the use of poison than to severity of attack.

YAMS.

SCALE INSECTS (*Aspidiotus hartii*).

GRENADA. Quite common in all districts.

ST. VINCENT. Seen in places but no extensive damage reported.

ANTIGUA. A fair proportion of the crop had on them, when reaped, some few specimens of this insect.

ST. KITTS. The yam crop generally was poor from bad weather conditions but there were no special signs of diseases. The yams after reaping get covered with a white scale.

PART II.—FUNGOID AND BACTERIAL DISEASES.

BY W. NOWELL. D.I.C.,

Mycologist on the Staff of the Imperial Department of Agriculture for the West Indies.

SUGAR CANE.

ROOT DISEASE (*Marasmius sacchari.* Wakker and allied species).

GRENADA. Attacked Bourbon variety severely on the Morne Rouge plot. Six other varieties in the plot were not visibly affected.

ST. LUCIA. Quite common in most fields and in some cases to a serious extent.

ANTIGUA. Common throughout the island; effect specially noticeable on ratoon canes growing in heavy lands. as well as on those planted in poor or badly drained fields.

ST. KITTS. Not so evident in the Basseterre district as in 1912 owing to better weather conditions. It is to be met with however on many estates and only needs poverty of soil and bad weather conditions to bring it into prominence.

NEVIS Observed on many estates; occurred to a greater extent than in 1912.

VIRGIN ISLANDS. Quite pronounced on ratoons. Variety B. 306 appeared most susceptible.

RIND FUNGUS (*Melanconium sacchari.* Massee).

ST. LUCIA. Common.

ANTIGUA. Common throughout the island, especially in fields of over-ripe cane. Frnctifications of this fungus always appear on cane some few days after cutting.

RED ROT DISEASE (*Colletotrichum falcatum*, Went.).

ANTIGUA. Isolated instances.

ST. KITTS. Estate badly affected in previous crop [which was reaped late] showed no signs of it this year.

PINE-APPLE DISEASE (*Thielaviopsis paradoxa* [ethaceticus], Maubl. et Griff.).

ANTIGUA. Fairly common in some few fields during the latter end of the year.

COTTON.

ANTHRACNOSE (*Colletotrichum gossypii*, Southw.).

ST. VINCENT. Very prevalent.

ANTIGUA. More common this season than for the previous two or three.

WEST INDIAN LEAF MILDEW.

ST. VINCENT. Prevalent in the latter part of the year.

ANTIGUA. Common in all fields. Not regarded as serious.

ST. KITTS Prevalent, especially in the wet districts when the plants were maturing. but little damage seemed to result as the bolls were well developed. In Anguilla during last season it has caused much damage and it appears to be new to the growers, who gave it the name of 'greasy fly'.

NEVIS. Found to a great extent in all the fields, especially during the months of December and January.

VIRGIN ISLANDS. Made its appearance late in the season.

BACTERIAL BOLL DISEASE, ANGULAR LEAF SPOT,

BLACK ARM (*Bacterium malvacearum*, Erw. Sm.).

ST. VINCENT. Caused, along with anthracnose, much damage owing to the wet season.

MONTSERRAT. There seemed to be a marked absence of bacterial disease on the first crop, but the second growth showed a fair amount of leaf spot and boll disease.

ANTIGUA. Fairly common on heavy lands in damp situations.

NEVIS. Boll disease observed in a few fields in December and January; leaf spot also observed in a few fields but not to any great extent.

OTHER BOLL DISEASES.

MONTSERRAT. The soft rot of cotton bolls (caused by a fungus in or near the genus Phytophthora) is always more or less present, particularly near the ground or in damp weather.

Late in the year it was found that a considerable proportion of the bolls of the second crop, although in outward appearance healthy, had discoloured lint.

ST. KITTS. In the late planted cotton many of the bolls turned black and dropped. Attributed to weather conditions.

VIRGIN ISLANDS. A 'black boll' disease was noticed.

CACAO.

ROOT DISEASE.

GRENADA. A very persistent attack is reported at an estate in St. Andrews. Other attacks readily surrendered to good cultural methods.

ST. LUCIA. General throughout the island, but outbreaks have not been so numerous as during the previous year. The Rosellinia disease has now been observed on Kola.

ST. KITTS. No record of any occurrence. The young trees at Molineux estate occasionally die off, as has been previously reported, but this has not been definitely put down to root disease.

CANKER (*Phytophthora Faberi*, Maubl.).

GRENADA. No serious attacks have been reported.

ST. LUCIA. Quite general but no serious attack reported.

DOMINICA. A number of trees of the delicate varieties growing at the Botanic Station went under to this disease during the year. A large number of trees of the Forastero type growing in unsuitable soil in the La Soye district were very badly attacked by canker. Attempts had been made to cut out the diseased tissue but there were ample signs of re-infection. Amelonada types growing amongst the Forastero trees seemed much less susceptible to attack.

ST. KITTS. A few trees at Molineux have been affected but have been successfully treated.

BLACK ROT OF PODS (*Phytophthora Faberi*).

ST. VINCENT. Seen in all fields. Nothing out of the ordinary observed or reported.

ST. LUCIA. Fairly common in some districts among peasants' cacao. The most common pod rot here.

DOMINICA. Observed in close association with the former, cankered stems bearing diseased pods.

BROWN ROT OF PODS. (*Thyridaria tarda*, Bancr.).

GRENADA. There has been an increase of this disease in most districts, probably due to abnormal weather conditions.

ST. LUCIA. Very common throughout the island and reported severe from certain estates in the Choiseul and Soufrière districts.

DOMINICA. A few brown pods invariably present in every picking of cacao. Not in any way serious.

There is considerable carelessness in the disposal of cacao husks. Only a few planters take the precaution of burying or liming the husks.

DIE-BACK AND STEM DISEASES (*Thyridaria tarda*).

GRENADA. Die-back observed in December on an estate in St. Andrews. The attack was fairly extensive but not severe when noted first.

ST. LUCIA. Of general occurrence.

DOMINICA. Generally prevalent.

VIRGIN ISLANDS. This form of disease was noticed.

PINK DISEASE (*Corticium lilacino-fuscum*, B. & C.),

ST. LUCIA. Not observed and not reported.

DOMINICA. Not observed during 1913.

THREAD BLIGHTS.

GRENADA. None on cacao this season.

ST. LUCIA. Not observed and not reported.

HORSE-HAIR BLIGHT (*Marasmius equcrinis*, Müller).

ST. LUCIA. Not observed and not reported.

DOMINICA. Observed in the interior of the island on cacao trees somewhat neglected.

MISCELLANEOUS FUNGI.

None reported.

LIMES AND OTHER CITRUS TREES.

BLACK ROOT DISEASE (*Rosellinia* sp.).

DOMINICA. Found most commonly on estates in the interior of the island, usually attacking good-sized, well-grown trees, thus causing alarm and annoyance. Apparently the disease is firmly established before the trees show any appearance of having been attacked, and the saving of attacked trees becomes difficult. Probably somewhat less prevalent than in former years.

ANTIGUA. It is extremely difficult to estimate amount of damage done by root diseases in lime fields. However, they do not appear to be increasing.

RED ROOT DISEASE (*Sphaerostilbe* sp.).

DOMINICA. Found on estates near the coast on both sides of the island. The attack reported last year is being controlled. Isolated dead trees here and there on estates appeared to have the fructifications of this disease at their bases. The best treatment appears to be to burn these stumps on the spot, followed by the digging out of as many roots as possible; burning these, then applying a liberal dressing of quicklime.

MISCELLANEOUS FUNGI.

ST. LUCIA. 'Damping off' among lime seedlings is reported from several estates as very severe.

Sweet Potatoes.

ROOT DISEASE *Marasmius* sp.

ANTIGUA. Found commonly in potatoes reaped from old cane fields. It does not seem to affect the yield of the plants. Possibly merely saprophytic on this crop.

Coco-nuts.

BUD ROT.

GRENADA. Sporadic cases of disease occurred and the trees were destroyed. Some of these may have been root disease.

ST VINCENT. One or two probable cases seen.

ST. LUCIA. No cases observed or reported.

ANTIGUA. No definite instance recorded.

MISCELLANEOUS FUNGI.

GRENADA. A few cases of stem canker noted, but none were severe.

Indian Corn.

ROOT DISEASE.

ANTIGUA. Sporadic attacks occurred. Possibly much of the damage attributed to this disease in previous years was caused by hardback grubs.

Guinea Corn and Imphee.

LEAF RUST.

ST. VINCENT. A good deal of it on imphee at the Experiment Station.

ANTIGUA. Commonly found in all fields of Guinea corn as the plants mature. Does not appear to be responsible for much damage

NEVIS. Observed on Guinea corn in many places but does not seem to be doing any damage.

Ground Nuts.

ROOT DISEASE.

GRENADA. The small cultivations at the Botanic Gardens and at Westerhall were slightly attacked.

LEAF RUST (*Uredo arachidis*, Lagh.).

ST. VINCENT. This was very prevalent in fields generally. Wet season no doubt the cause.

MONTSERRAT. This pest attacked the plants as usual at about three months from planting.

ANTIGUA. Noticed in mature plants in Experiment Station.

LEAF SPOT (*Cercospora personata*, Ellis).

ST. KITTS. None to do any damage.

ONIONS.

BACTERIAL ROT.

ST. KITTS. No occurrence of this in the field, but onions reaped kept very badly and much loss was sustained from rotting.

ANTIGUA. Not noticed in the field. Isolated instances found on onions after harvesting.

YAMS.

TUBER DISEASE.

ANTIGUA. A disease causing rotting of the tubers in the field was recorded for the first time from three places in Antigua. Very little is known about this disease locally.

RUBBER (CASTILLOA).

BLACK ROOT DISEASE (*Rosellinia* sp.).

ST. LUCIA. Reported from one state.

GRENADA. A few trees were killed at the Grand Etang by this disease.

GREEN DRESSINGS.

ST. LUCIA. *Crotalaria verrucosa* was severely attacked by what appeared to be a root disease: white mycelium covering the stem just above the soil level. *C. striata* growing in the same plot, separated by a 3-foot row of sugar-cane was unaffected.

GENERAL.

LOVE VINE (*Cuscuta* sp.).

GRENADA. Love vine is handled fairly systematically by the Government sanitary inspectors acting unper the Noxious Weeds Ordinance.

ST. LUCIA. Love vine has become so common a pest that legislation is necessary.

DOMINICA. Enquiries made during the year show that this pest is confined to certain fairly well-defined portions of the island. In the districts where it is found it causes much damage to crops, more especially cassava, limes and cacao, and trees forming wind-breaks.

ANTIGUA. There is a decided decrease in the quantity of love vine during the season under report when compared with the previous ones.

ST. KITTS. Love vine is plentiful in some districts but no trees of any value are attacked. ('Old Man's Beard,' *Tillandsia* spp., is a great nuisance on some trees.)

NEVIS. Love vine observed on hedges, but not attacking any cultivated plant.

VIRGIN ISLANDS. Love vine prevalent in lime plantations.

MISTLETOE (*Loranthus* sp., *Phoradendron* sp.).

GRENADA. On peasant holdings mistletoe continues to be neglected.

ST. LUCIA. Mistletoe is far too commonly met with on mature trees adjoining lime estates, and many cases of spreading to this cultivation have occurred. The serious nature of this parasite is evidently not generally appreciated, as is evidenced by its presence in large quantities in public situations from which one would have expected it to be immediately eradicated.

DOMINICA. Certain properties continued badly infested with mistletoe. The sharpest lookout and immediate action are required to keep this pest within control.

CONTROL OF INJURIOUS INSECTS BY FUNGI.

GRENADA. The red-headed fungus (*Sphaerostilbe coccophila*) is gradually coming into prominence as a control of black line scale and orange mussel scale. Shield scale fungus (*Cephalosporium lecanii*) still does good work on mango scales.

ST. LUCIA. The white-headed fungus (*Ophionectria coccicola*) is spreading rapidly, chiefly through artificial introduction from one district to another. The red-headed fungus and black fungus (*Myriangium Duriaei*) are found generally throughout the island. The shield scale fungus is still comparatively rare.

DOMINICA. These continue to exert a most effective check on th numbers of scale and other insects in Dominica.

ANTIGUA. The shield scale fungus has done much towards clearing trees in one locality. The red-headed and black fungi are common in lime fields.

ST. KITTS. There are very few fungus enemies of insects, as they do not seem to thrive under the dry conditions which exist in St. Kitts at certain times of the year.

GENERAL REMARKS.

DOMINICA. Coco-nuts and rubber trees continue remarkably free from attacks of insects and fungus diseases. No diseased trees of either of the above were observed, or reported to this Department.

ST. KITTS. Generally speaking, the year under review has been particularly free from any serious pests to cane or cotton and no new pest has been found.

SUMMARY OF DISTRIBUTION.

The following table is intended to show the status and distribution of the insects, fungi, and vegetable parasites attacking the principal crops. It has been drawn up from the information available at the Head Office of the Department, and has not been re-submitted to the officers in the various islands. While not claiming to be exact, it may be taken as affording, so far as the entries are positive, a fair summary of the position during the year in question. A blank space means in many cases that the crop referred to is not grown to any important extent in that particular island, or it may mean that the insect or fungus is not familiar to the observer, or has not been noticed, or again that it is actually absent. It may in general be taken as indicating that the insect or fungus, unless it is an obscure one is not prevalent to any serious degree.

EXPLANATION OF SIGNS USED.

g = generally distributed.

G = generally distributed, severe.

l = local.

L = locally severe.

r = recorded present.

? = doubtful.

INSECT PESTS.

	Grenada.	S. Vincent.	S. Lucia.	Dominica.	Montserrat.	Antigua.	S. Kitts.	Nevis.	Virgin Islands.
CACAO.									
Thrips	g	L	?	l					
Beetle	g								
Scale Insects and Mealy-bugs ...	l						l		
Termites	l								
COCO-NUTS.									
Weevil		r							
White Fly		r					?	o	
Scale Insects	g		g			g	r	g	r
CORN (INDIAN).									
Corn Ear Worm		L	g L		g	g	g L	g	
Hard Back Grubs					?	g L			
COTTON.									
Cotton Worm		?	l		g	G	G	g L	l
Boll Worm						g			
Cotton Stainers		g	r		g	g	g	g	g
Scale Insects		l	r		r		r	g	r
Flower-bud Maggot					o	L			
Leaf-blister Mite		r	r		g	g	r	g	G
Aphis						l		l	r
Lachnopus Weevil							L		
GREEN DRESSINGS.									
Leaf-eating Caterpillars									
GROUND NUTS.									
Green Bug									
Caterpillars									
LIMES AND OTHER CITRUS TREES.									
Scale Insects	g	G	g	g	g	g	G	g	r
Bark Borer			l	l					
Twig Borer						l			
Orange Moth				l					

INSECT PESTS.—*Concluded.*

	Grenada.	S. Vincent.	S. Lucia.	Dominica.	Montser at.	Antigua.	S. Kitts.	Nevis.	Virgin Islands.
ONIONS.									
Caterpillars						g		g	
Thrips						g			
RUBBER.									
Scale Insects			g				r		
SUGAR-CANE.									
Moth Borer	g	r	r			r	g	g	r
Weevil Borer			g			g	l		
Root Borer			r				l		
Cane Fly									
Termites						g	l		
Hard Back Grubs...			r			g	l	r	
Scale Insects and Mealy-bugs ...						g			
Grasshoppers			g			l	g		
SWEET POTATOES.									
Caterpillars			l			l			r
Scarabee	g	g				?	?	L	r
Red Spider			r			g			
Thrips						r			
YAMS.									
Scale Insects on tubers	g	l				g	g		

FUNGOID DISEASES.

	Grenada.	S. Vincent.	S. Lucia.	Dominica.	Montserrat.	Antigua.	S. Kitts.	Nevis.	Virgin Islands.
CACAO.									
Root Disease	L		g						
Canker	g		g	g L			l		
Die-back and Stem Diseases ...	l		g	g					
Brown Pod Rot	g		g L	g					
Black Pod Rot		g	g	g					
Pink Disease									
Thread Blight									
Horse-hair Blight				r					
Other Diseases									
COCO-NUTS.									
Bud Rot	?	?				?			
Other Diseases	l								
CORN (INDIAN).									
Root Disease						l			
COTTON.									
Anthracnose		G				g			
Bacterial Boll Disease		G			g	l		l	?
Angular Leaf Spot					g	l		l	
Black Arm									
West Indian Leaf Mildew ...		g				g	g L	G ?	g
Other Diseases					L		L		
GREEN DRESSINGS.									
Root Disease			L						
GROUND NUTS.									
Root Disease	l								
Rust		G			g	l			
Leaf Spot							?		
Other Diseases									
GIUNEA CORN AND IMPHEE.									
Rust		L				g		g	

FUNGOID DISEASES.—*Concluded.*

	Grenada.	S. Vincent.	S. Lucia.	Dominica.	Montserrat.	Antigua.	S. Kitts.	Nevis.	Virgin Islands.
LIMES AND OTHER CITRUS TREES.									
Root Canker						?			
Black Root Disease				L		?			
Red Root Disease				l		?			
Other Diseases			L						
ONIONS									
Bacterial Rot						l	G ?		
RUBBER.									
Black Root Disease (Castilloa) .	r		r						
Other Diseases									
SUGAR-CANE.									
Root Disease	g L		g L			g L	gL	gL	gL
Rind Fungus			g			g			
Red Rot						l			
Pine-apple Disease						l			
Other Diseases									
SWEET POTATOES.									
Root Disease						r			
Other Diseases									
YAMS.									
Tuber Disease						l			
Other Diseases									
PHANEROGAMIC PARASITES.									
Love Vine	g		G	L		g	g	g	g
Mistletoe	l		L	L					

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THE PRODUCTION OF PORK AND BACON.

A NEW INDUSTRY FOR THE WEST INDIES.

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It is widely recognized that there is real need for the greater diversification of agricultural industries in most of the West Indian islands, and that if this can be accomplished, important results of a beneficial nature are likely to accrue. This need has been ever present in the minds of those responsible for agricultural development, and already notable results have been attained in some directions. We have the development of the Cacao industry in Grenada and other colonies following upon the sugar crisis of the early eighties; the development of the lime industry, which has reached so marked a pitch in Dominica, and the development of the cotton industry, which has added much to the prosperity of many West Indian islands, amongst which may be mentioned St. Vincent, St. Kitts, Nevis, and Montserrat.

These instances suffice to show the beneficial effects that have followed the successful establishment of industries which have become staple ones in the colonies concerned. There yet remain many districts where new industries are needed, and one may well suppose that equally beneficial results remain to be reaped from successful exploration into new industrial regions.

Careful consideration has convinced me that a large field for development, larger indeed than any of those just referred to, awaits exploitation in the form of pig raising, with its accompanying production of bacon, pork, and other important subsidiary products.

The raising of pigs, by opening a phase of agriculture entirely new to the West Indies, would develop possibilities of a widely extended kind ; it would revolutionize agricultural ideas and admit of the utilization of land and of products at present of little service, making them important as sources of wealth.

To all who know the West Indian islands it is evident that pigs thrive well and, in a small way, already have some industrial value. What has hitherto prevented the existing small industry from assuming important dimensions is the limited market available under existing conditions.

There appears no reason, however, why, as the outcome of the development of refrigerating machinery, bacon and pork products should not be raised in the West Indies, to find a market in Europe and America. These markets are now feeling the effect of a diminution of supplies so that prices have advanced over 30 per cent. in the last five years. New sources of supply are urgently needed, and it is evident that the time is opportune for the West Indies to come forward as suppliers of a market likely to be faced with somewhat short supplies for some time to come.

The market into which it is proposed to enter is a vast one Some idea of its importance may be gained when it is stated that the importations into England are, as shown in the following table, of an annual value of some twenty millions sterling.

Description.	Quantity.		Value.	
	1912.	1913.	1912.	1913.
	Cwt.	Cwt.	£	£
Pork, fresh and refrigerated ...	312,739	495,864	830,743	1,369,360
Pork, salted ...	213,238	240,943	270,265	289,275
Bacon	4,634,099	4,875,890	14,555,548	17,428,881
Hams	897,876	854,995	2,720,379	3,068,251

In order that anything effective may be done, it is clear that the new enterprise must be entered upon on a large scale, and that for successes to follow, it is essential that there shall be large developments and effective organization from the outset; small scattered individual efforts will be of no avail.

From the nature of the case it is obvious that from the beginning of the enterprise, assurance must be given of the adequate preparation of the commodities concerned, and of their proper entry upon the vast markets to which they are to be sent. While it may be possible for West Indian planters, by careful

thought and under careful guidance to succeed in the raising of pigs, it is evident that they do not possess the requisite knowledge of the bacon-curing and pork-packing business, or of the conditions and requirements of markets, to enable them, unaided, safely to embark on the undertaking in view.

To carry into effect what I believe to be an important and lucrative venture, it will be necessary from the outset to enter into arrangements with those who are perfectly familiar with the manufacturing, packing, and marketing side of the business. It appears to me that this may be best effected by the formation of a company or companies, which will undertake to purchase pigs from the growers on a profit-sharing basis, and who will undertake to erect and operate a series of bacon-curing and pork-packing factories in various places in the West Indies. Briefly stated, the position would be that the company should purchase pigs from the growers, convert them into marketable products, and sell them, on profit-sharing lines, just as the large sugar factory companies, such as exist in Antigua, St. Kitts and elsewhere deal with sugar-canes and sugar. The planters on their part should enter into agreements to raise the pigs, and to furnish all that they raise to the company.

I have already given some consideration to the manner in which this business may be conducted as a profit-sharing enterprise, but it is unnecessary to burden this preliminary communication with attempts to develop plans in detail.

The existence in practically every island of the West Indies of a body of planters who are in a position at once to consider the question of embarking on such an industry as that proposed, who are anxious to find new outlets for the produce of their land, who are even now producing considerable quantities of material that may be used for feeding pigs, and are able at short notice rapidly to increase these amounts, makes it possible to think of starting the enterprise on the considerable scale that is necessary to ensure success. The existence of this compact body in possession of all the facilities for the business, and ready at once to get to work, is a feature of importance not commonly met with in contemplating new developments, and one which has an important bearing on the success of the enterprise.

Looked at from the West Indian point of view, there are large areas in many of the islands eminently suited to pig-raising: readers acquainted with individual islands will readily see how large, and how suitable for the purpose are the districts in view. In the first place there are considerable areas under cultivation in sugar-cane, which are at present yielding unremunerative returns from the production of muscovado sugar, and there is little prospect of modern sugar factories being erected in many of these. Such areas exist in Antigua, Montserrat, Nevis, and possibly in St. Kitts, and elsewhere here are also even larger areas suitable for cultivation in sugar and other crops now lying idle or imperfectly occupied because it is impossible to find any crop that may be profitably grown and marketed. Low prices and difficulties of transport have rendered these lands of little use to their owners. Very large areas so circumstanced

may be readily made available for pig raising, for here we have a commodity of which the supply is short and prices are rising, and which moreover solves many of the difficulties of transport, for the pig can transport himself, for moderate and sufficient distances, over roads and paths unsuitable for wheeled traffic, thus removing one of the greatest obstacles in the way of developing many extensive and fertile tracts that exist in practically every island.

In the matter of food supplies for raising pigs, the West Indian islands are most favourably situated In the first place there are considerable areas on which sugar-cane is now growing under unremunerative conditions, while they are still larger areas on which it may be grown if it can be conveniently disposed of. It is anticipated that it may be found profitable to feed the sugar cane so grown, direct to pigs, thus affording a new and important use for this readily grown crop. These lands are also capable of producing abundant supplies of important foodstuffs such as Guinea corn, pigeon peas, sweet potatoes, cassava, beans, maize and tropical food crops generally.

The raising of proper rotation of crops for feeding pigs, and the skilful adjustment of these to the requirements of the industry will constitute an important part of agricultural thought and development; there is, however, no doubt concerning the ability to raise considerable quantities of suitable foodstuffs, and ample land on which to do it.

At present there are many by-products and waste products that may be used to advantage in pig raising. The correct appreciation of the best means of using these will afford a fertile field for study and investigation; it is possible even now to indicate some of these that may be of value.

Of late years increasing difficulty has been experienced in disposing of the large quantities of molasses produced in the sugar-cane industry. With the extension of modern machinery in large sugar factories, the difficulty of disposing of molasses has increased, for the molasses produced by these factories is not of a quality suitable for human food, though in proper association with other materials it is a suitable food for pigs and stock. Owing to the cost of freight and packages, which is high in proportion to the value of the material itself, it is found difficult to place this commodity in European or American markets. Thus there is available locally a very large quantity of molasses eminently suited for feeding pigs. For example, the large central sugar factories of Antigua and St. Kitts will each produce in a season some 200,000 gallons of molasses available for this purpose, and there are many other sources of supply.

Another waste product of the sugar factories, which may be used to great advantage as food for pigs, is the filter-press cake which contains a considerable quantity of protein and of sugar. It is a valuable food for animals for which at present there is little use except as manure. It may be taken that the quantity of filter-press cake produced is approximately equal to one per cent. of the weight of the cane crushed at a factory, consequently the Antigua and St. Kitts central factories are each producing 700 to 800 tons of filter-press cake, and from other factories, there

are amounts in similar proportion. This material may be regarded for this purpose as being as useful as barley or oats: each of these factories referred to at Antigua and St. Kitts would therefore provide the principle part of the food for 1,000 pigs in each season.

Passing reference may be made to the waste materials of arrowroot works which contain much valuable food, and to the refuse lime skins of lime juice factories which are readily eaten by pigs; also to such materials as bananas, large quantities of which are unable to be shipped, and for which some outlet is urgently required; to coco-nut by-products and many other substances now wasted, but constituting useful animal food.

Unfortunately, cotton seed, which is now produced in large quantities in the West Indies, does not form a suitable food for pigs.

Without, at this preliminary stage, attempting to consider in detail the possibilities presented in this connexion by each individual island, it may suffice if it is suggested that each island would probably find no difficulty in profitably raising 20,000 to 30,000 pigs in a season. The addition to the agricultural wealth of each island which such an industry implies, is very great: there are grounds for thinking that for some islands, the production of pork and bacon may readily become the main staple industry.

In starting the industry very great care will have to be exercised in the choice of suitable breeds of pigs. It will probably be found that such breeds as Duroc-Jersey, Poland-China, Berkshire, and Tamworth are suitable, but it will be well to arrange for the careful introduction of well bred animals, and in this it is probable that assistance may be given by the company, whose business it will be to provide the necessary factory, and arrange the details of disposing of the produce.

It may be well to point out at the outset, that in the event of a planter undertaking to raise pigs for a factory, he will require to study very closely and carefully the art of feeding and preparing for market the animals he undertakes to raise. The work must be undertaken in an intelligent manner; knowledge must be gained concerning the value for the end in view of all the forms of food available. This opens up a large and new field for the consideration not only of planters, but also of the Agricultural Departments and Experiment Stations, and one may look forward with satisfaction to the probable effects on the development of each colony, of the outcome of this stimulation of ideas.

It has been suggested that bacon produced in the West Indies may have the defect known as softness. It is, however, well known that softness is a feature appearing not only in warm climates, but also in countries with a cold climate. Softness is by no means uncommon, for example, in Canada. Recent researches appear to have demonstrated that softness is largely traceable to the methods of feeding, and that certain oily foods, such as some maize products and oilmeals, may accentuate this feature.

Opportunity has recently been taken to examine the fat of pigs raised in several West Indian islands. The results appear to

show, that under the present conditions of feeding, the fat tends to exhibit firmness rather than softness.

If pig-raising for bacon purposes is to be undertaken in the West Indies, it is evident that the business must, from the outset, be conducted on well organized lines under scientific direction. In this way it will be possible in the early stages of the industry, and before any considerable numbers of pigs are ready for market, to make careful investigations as to the effects of various forms of feeding, and as to general conditions of raising and maturing, so that the business may be placed on a sound basis.

Fortunately the conditions existing in the West Indies are eminently favourable to development on sound lines, in that, as already stated, the planters are ready to embark on new industries, while ample facilities for their side of the business already exist. At the same time it may be remembered that in every colony there is an Agricultural Department which, either in itself or through its associated agencies, is able to assist in carrying out experiments to elucidate the problems that are sure to confront any new industry ; to afford advice concerning the food materials available, and the best means of using them ; and to assist in directing those co-operative experiments which will assuredly be found necessary to determine the best conditions of working.

What remains to be done is to secure the formation of companies possessing the necessary capital to equip and work the bacon-curing and pork-packing factories on an adequate scale, and who are also in possession of full knowledge of all the requirements of the markets for the products to be turned out, and of the intimate details of the business, so that every portion of the slaughtered pig may be utilized to the best advantage.

At the same time, it is open to suggestion that the position is of sufficient importance to warrant Government assistance, particularly in the early stages of the enterprise.

It is recognized that a large amount of work remains to be done in order to organize the business of producing, selling, manufacturing, and marketing, with its many and diverse elements, on a satisfactory basis; but that it can be done, and that in a short period of years, I am fully convinced.

As a stimulus to action, it may be worth while to consider what beneficial effects would follow the introduction of an entirely new form of industry, with the possibilities of employing land and crops at present of little value. Trinidad may add greatly to its agricultural revenues by such a development, while the islands of Antigua, St. Kitts, Nevis, Montserrat, and St. Vincent are pre-eminently suited for the undertaking in view. Those who know these last named islands, and their agricultural and fiscal conditions, can form their own conclusions as to the advantages that would accrue to them, if each were exporting the product of some 20,000 to 30,000 pigs annually.

The present moment is a favourable one for considering the proposition now set out. The supplies of bacon from the United States to England are decreasing, as are also those from Canada. The following extracts relating to the provision trade in January

1914, taken from the *Journal of the Board of Agriculture* (Great Britain) for February 1914, clearly indicate the condition of the market and its prospects :—

'The scarcity of both English and Irish pigs continues to cause anxiety amongst curers, and it is generally expected that the present high prices will be maintained, the supply not being sufficient to fill the demand.

'All advices from America point to strong markets, and packers demand extreme prices for forward shipments, anticipating that the raw material will cost them more.

'The American Hog Census, as taken on January 1, shows a shrinkage of about 3 per cent., the figures being 58,933,000 as against 61,178, 000 last year, and 65,620,000 three years ago.

'Canada continues to send less bacon to England, and there are prospects of a still larger reduction in the quantity available for export from the Dominion. In 1913, 12,176 tons were shipped to this country, against 30,790 tons two years ago (1911).'

New fields of supply are being sought, even such distant sources as China being exploited. With these facts in view, it appears evident that the West Indies have an opportunity of establishing a large, remunerative, and important new industry, and that it is expedient now to give the matter serious consideration.

IMPORTS INTO THE WEST INDIES OF SALTED PORK, HAMS AND BACON DURING THE YEAR 1912.

Colony.	Hams and Bacon		Pork.	
	lb.	£	lb.	£
Trinidad ...	411,796	12,961	4,102,467*	60,358
British Guiana	271,372	10,154	1,578,200	26,209
Barbados ...	183,111	4,578	1,104,227	23,005
Grenada ...	38,191	1,415	314,515†	6,000
St. Vincent ...	8,445	360	83,000	1,636
St. Lucia ...	19,370	720	115,808†	2,090
Antigua ...	10,210	653	235,231	4,870
St. Kitts ...	25,496	1,058	282,300	5,393
Dominica ...	12,191	536	62,905	980
Montserrat ...	2,242	96	12,600	268
	982,427	32,531	7,891,283	130,809

* Meats in brine.
† Includes salted beef.

COMMERCE AND SCIENCE IN COTTON GROWING*.

BY MR. J. W. McCONNEL.

The primary object of this paper is to put before the Congress some thoughts in regard to the objective which should be aimed at by cotton breeders and cotton growers. I propose to elaborate a letter on the same subject which I wrote to the *Textile Mercury* in March. In writing that letter I only had in view cottons suitable for fine yarns; but I think the same considerations are pertinent, at least to some extent, to the growing of all cottons. It may be that in the United States of America cotton has been grown hitherto so as to give fairly satisfactory results to the grower, without any particular attention being given to scientific considerations. So far as this is the case, it is due to the fact that cotton growing in America is an inherited industry. For over a hundred years—practically for the whole period of commercial cotton spinning—America has been in the position of supplying the standard cottons of the trade. It is probably more true to say that cotton spinning has been elaborated so as to handle in the best possible way the cotton from America, than to claim that America has envolved cotton specially suitable for spinners.

But whatever may be the truth about America, there can be no question that in other countries, success in cotton growing can only be obtained by the application of scientific principles. India affords an object-lesson of a sad kind. There, there is a great industry—in the sense that millions of acres of land are employed; great again in the sense that millions of people work at it; great again in the sense that it is an ancient industry with a great historic past. In every other sense it is a sadly little industry. It produces a pitifully small quantity of indifferent quality. Scientific principles have been ignored in the past. It is to be hoped that the new efforts now being made will produce good results, but I fear that the Government are still very far from recognizing that liberal expenditure on scientific work in cotton growing and in agriculture generally, is the only foundation on which prosperity for India can be built. The story of cotton in Egypt is happier, but it teaches the same lesson. Apparently its early successes were largely due to the strong hand of Mohammed Ali, compelling the use of the best seed and the best methods of growing known to his day. And subsequently I think that Egyptian cottons have just maintained a balance between the tendencies of Nature to deteriorate, and the efforts of human agents to improve. In the newer cotton-growing countries—which, as it happens, are nearly all in the Tropics, and thus directly connected with this Congress—I am sure that success depends entirely on the application of the best scientific learning to what is necessarily a very difficult problem.

The difficulty of growing good cotton lies in several facts. First of all, there is no natural cotton that is good. All its good

* A paper read at the International Congress of Tropical Agriculture, London, July 1914.

qualities have to be given to it by human agency, or at least have to be caught and kept by human agents whenever Nature chances to give something good. Otherwise, Nature will hurriedly destroy the good characteristic. But, on the other side, there is the curious difficulty of knowing what is good. Cotton is not a food or drink, whose merits can be appreciated by the grower himself. Cotton again is not capable of valuation by chemical analysis. Nor can it be readily and easily tested for quality in its natural state. He who would grow good cotton is confronted with the difficulty of knowing what is good. The question how good qualities can be added to or increased in vegetable growths is, I suppose, in itself a problem for agronomists. But in cotton the question that has first to be settled is, What does the spinner want? And conversely, How is the grower with a handful of new plants to judge their relative merits? Then there is the further difficulty that the spinner can only answer the question very imperfectly. A spinner is not necessarily a scientist. In all the century and a quarter during which the cotton trade has grown to greatness, it would have been nearly useless for the spinner to spend time in studying tho laws that govern quality in cotton—useless, because he knew ne one who would have tried to give the special characteristics required. The actual sequence of events, I think, has largely been that the grower has grown what chanced to grow, and the spinner has adapted his machinery to deal with it. And by 'rule of thumb' the spinner has bought what suited him the best, and the grower has used the seed which promised the best results to himself.

At the present time things are different. In every country where it has been sought to introduce cotton as a new product, its difficulties have compelled people to study its nature, and it is largely owing to the Agricultural Departments that so much progress in this knowledge has recently been made. Again, the organization of the Imperial Institute, and the formation of the technological departments in our municipalities, and at the Universities, havemade possible research work on the nature of the fibre. In the United States some interesting experiments are in process of being made, with the object of ascertaining the practical differences to the mill arising from the use of cottons of different grades, these grades being classified under the new Official Standards. I may quote some useful words from Bulletin No. 62, which reports progress so far made. Mr. W. A. Taylor says therein: 'The Official Grades at present take cognisance of only two qualities, viz: (1) the colour, and (2) the amount of trash and waste matter. Any complete system of standardization of cotton will, however, have to take into consideration, among other things, (3) the length of the fibre, (4) the strength of the fibre, (5) the clinging qualities of the fibre, and (6) the bleaching qualities of the fibre.'

This is aiming high; it is indeed a fine ideal, and the business of the spinner will be simplified, and the products of the mill improved, if the time ever comes when official valuations take properly into consideration the spinning merits of cotton as apart rom its mere appearance. Mr. Taylor's list of qualities is good

Except for two omissions it seems practically to cover what a spinner is looking for.

(1) Colour is important in many cases. There are occasionally sold articles of wear in which the dead white of American 'Upland', or the pearly white of 'Abassi' are required; there are others which make their market by their natural brown. But as a rule the value of colour to a spinner is that his customers consider it an index of quality: if he changes the colour or shade of his cotton, his customers are suspicious that the quality of the yarn has also been changed. I think also, that to cotton growers colour may very probably be of great value as an index of purity, or of trueness to type.

(2) Amount of Trash and Waste. This is of the first importance commercially. Mr. Taylor says that the mill experiments with cottons of the various official standards show visible waste, varying from 4 per cent. in Middling Fair to about 11 per cent in Good Ordinary. If this be confirmed by the fuller report which is promised later, it shows the question of waste to be an even more important one to the general bulk of spinners than I should have expected. I know its great importance to fine spinners. But on the figures given, it means that if Middling Fair is worth *8d.* per ℔, containing 4 per cent. of waste, then Good Ordinary will cost the spinner as much, if he pays 7·42*d.* for it. Of course, in addition the yarn made from the poorer cotton will still be poorer, even when this extra percentage of waste has been removed. Mr. Taylor speaks only of visible waste. Invisible waste—which may consist of damp, whether natural or fraudulent, or of dust—is equally important. I may mention a new cotton I once tried. It was attractive in appearance, but the fibres broke up into dust to such an extent that it was almost impossible to make a yarn at all, and quite impossible to make a yarn of the same counts, i.e., of the same thickness, as usual.

This question of waste is one for scientific breeders. Waste may be trash, due to the leaf or to the shape of the boll. Waste may be immature fibres, due to the fibre formation on the seed, which I am told is an inherited quality. There may be other inherited causes. Or irregular fibres may be due to irregular plant food. Nature unaided will give us little but waste. It is to human science that we look for good cotton.

(3), (4), (5). Length of fibre, Strength of fibre, and Clinging qualities. Mr. Taylor rather curiously omits Fineness. Cotton yarns vary in value according to their cleanliness, which is affected by the amount and kind of waste. They also vary in value according to their fineness, their strength, and their regularity. These qualities of fineness, strength, and regularity in yarns depend primarily on the cotton. Cotton therefore is valuable to a spinner in proportion as it gives him these qualities in his yarns. Now I imagine that these qualities in yarns come from length and strength and fineness of fibre, and from some other qualities which Mr. Taylor calls 'clinging' qualities. The well-known convolutions no doubt affect this clinging, and probably also some characteristics of the nature of flexibility of skin not easy to ascertain or define; a spinner sometimes speaks

of them as 'oiliness'. I think that no one knows what are the exact relations between these characteristics in the fibre, and the qualities we desire for our yarns. There is, I am sure, room for research work on this point. There is also urgent necessity for corresponding research work by cotton-growing scientists, as to the means by which they are to produce those qualities in cotton which the textile laboratory finds to give the required results in yarn.

Now I pass from the spinner's requirements to a matter which concerns both him and the grower: and that is, that cotton should be cheap. The American orator proclaims, 'Cotton is King.'! True, but it is a limited monarchy. To remain King, cotton must be popular, cotton must be cheap. Cheapness does not mean want of proper profit for the grower: it does mean that all the resources of science must be employed to produce large crops per acre. Suitable cultivation, suitable manures, must be employed; but above all it rests with the plant breeder to evolve a cotton plant whose purpose in life is to make cotton, not wood or cotton seed. The plant must also be energetic, and ripen its fibre quickly, so that men can get it and not the insects. There is no necessary conflict in cotton between quality and quantity. The Sakellarides cotton in Egypt, the Cambodia in India, have proved that it is possible to make cotton more valuable to a spinner, and at the same time more prolific and therefore less expensive to the grower. Here, then, is another objective for the cotton-growing scientist.

I suppose—though I do not actually know—that in each country some obscure laws of climate and soil eventually prescribe what cottons can be grown prolifically. It is for the individual planter and for the Economic Department of each Government to ascertain within these limits what kind of cotton will give the greatest monetary return. This is roughly the product of two factors—quantity of lint production multiplied by price obtainable. The relative price obtainable for any cotton as compared with others which might be grown is necessarily variable. It varies partly as the world's needs alter. It varies still more as the quantity produced increases or decreases. Sakellarides has spoilt its price by its own productivity: but it will still be grown in Egypt, because it pays the grower even at the lower price. And in a few years, if its excellence is preserved, it will regain its price, because the spinners who once use it can never go back to a poorer cotton. I suggest here as a broad rule for every country and for every plantation, that it is bad business to grow cotton of small value per pound instead of higher priced cotton, unless the cheaper cotton is so prolific that its extra quantity makes up for its lower price.

We can now define to some extent the questions to be answered by any paternal Government which desires its subjects to produce cotton. Some of the questions are: Can cotton be grown regularly one year after another? This depends on soil and climate. Is there labour available for growing and picking? What kinds of cotton can be grown, and therefore what price may be expected in the market? What will be the cost of carriage and merchanting? And therefore, will the price that remains or

the grower give him a reasonable return when multiplied by the quantity he can grow? Will it pay him as well as other crops possible to be grown?

For more advanced communities, the questions which arise are easy to state but exceedingly difficult to answer. Two questions cover the whole field; they are, How can the cottons grown be so improved as to be worth more money? and, How can they be made more prolific, so that the results of growing them will be better for the grower? The answers to both questions lie in the sphere of thought which I have attempted to indicate.

But there is one quality more, not named by Mr. Taylor, and yet I think the most important of all to growers and to spinners. I refer to Uniformity. In all the qualities a spinner wants in cotton—namely, fineness and strength and length and adhesiveness and colour and freedom from waste—in each and every case uniformity is essential, if the quality is to be worth money. To be partly fine is to be coarse; to be partly strong is to be weak; to be irregular in length or colour or anything else is to be so far poorer and less valuable. Also irregularity in plant habit is a certain bar to a big production. Now I believe that this virtue of uniformity, this *sine qua non*, without which no goodness is good, I believe that this is now for the first time in the history of cotton within reach of attainment. Uniformity can only be hoped for from plants that will breed pure. A pure plant may conceivably fail in uniformity, but without purity uniformity is inconceivable.

Now it is well known to all students of cotton growing that the work of Mr. Lawrence Balls in Egypt, and of others elsewhere, has shown that it is possible to cultivate cotton on a commercial scale from pure parents. There is a good deal of evidence that purity in itself gives value to cotton. The best practical cotton growers of my acquaintance attach the first importance to purity, even where they have not hit on Mr. Balls's system of securing it. The experiments of the Americans with Egyptian seed in Arizona bear a curious testimony to this principle. So long as they used imported seed the results were poor; but by selection, or by accident, they struck on an indigenous offshoot from the original Metafifi. Some of the cotton from this is as much superior to the best Sakellarides as that is superior to anything else in Egypt. They are not working on Mr. Balls's system, and in practice the commercial crop from this cotton is too much mixed to be of any great value. But the testimony to the value of purity lies in the description of his experiments given by Mr. Kearney. Year after year he comments on the prepotency of his new cotton, and on its resistance to hybridization. It is evident that Nature was here making one of her rare efforts to produce a pure cotton, and that so far as she succeeded, she was producing something exceptionally good.

But the most striking evidence of the value of purity is to be found in the mill tests of Mr. Balls's own cottons. Four samples of pure strains were selected for examination. The finger test of Alexandrian valuers found one to be good, the others indifferent.

I may admit that the judgement of practical spinners was not entirely at variance with this, but the mill test was very different. Of the four samples, one represented an attempt to develop a substitute for Sea Island cotton. In the first instance it was unfortunately not tested on this basis in the mill. No exact report can be given, but the cotton was reported to be neppy and wasty, but strong. I have subsequently had a small sample put through a mill which spins only fine Sea Island cottons. The experimental cotton proves to be very wasty, i.e., to have a large excess of imperfect fibres; but when spun into yarn so fine as 188's, it is about 9 per cent. stronger than the standard of the mill, and is about equal in appearance.

The other three samples were tested against Nubari, classified as 'Good'. This showed a loss of about 18 per cent. of waste, and gave a strength of 10·00 lb. One sample (which I will call 'A',) showed 16·8 per cent. waste, and strength 12·50 lb.; this I understand to be from Assili parentage, and to be extraordinarily prolific. 'B' showed 17·5 per cent. waste, and strength 14·00 lb.; this is the cotton that was approved in Alexandria. 'C' showed 15·7 per cent. waste, and strength 16·30 lb. Considering that the comparison was made against Nubari cotton classing 'Good', which is far above the average of Egyptian cotton, it must be admitted that these are remarkable results: the waste in each case is less, and the strength much greater. It is unfortunate that the bulk of the cotton grown from these four strains was sold off before the results of our experimental tests were known. Thus there has been no opportunity of qualifying or confirming the tests on a large scale; but I may say that I have had a second test made with small samples in another mill—and again all three samples are stronger than Good Nubari, and again Sample 'C', in which uniformity is the most noticeable characteristic, comes out the strongest of the lot.

Gentlemen, I make two suggestions:—

In the first place, I suggest that arrangements ought to be made either at the Imperial Institute, or in Manchester (perhaps preferably in Manchester), so that small quantities of cotton can be practically tested under conditions resembling those of an ordinary mill. In experienced hands a trustworthy test can be made with a pound weight of cotton, or even less. If some such practical testing were regularly available, it would greatly assist the scientific breeders and laboratory workers in cotton-growing countries, because they would not only be able to send small samples to be submitted to the test—they would also be enabled to bring their laboratory experiments on single bolls and single fibres into closer relation with mill practice than is now possible.

Secondly, I commend to all who are practically engaged in cotton breeding or cotton growing that purity should be their principal objective. Hitherto the whole character of the plant has been a chance entanglement of qualities, and improvement a nearly insoluble problem. When pure strains become generally available, the processes of improvement in quality or in quantity, or of gradual modification in any desired direction, will become possible—and growers and spinners will both be benefitted.

BORDEAUX MIXTURE.

In the June 1914 issue of *Phytopathology*, Mr. O. Butler has placed on record an interesting and important review of the present knowledge concerning the physical and chemical properties of Bordeaux mixture, thorough understanding of these being held essential to a study of the biological action. He traces the origin of the use of sulphate of copper and lime as a deterrent from theft in connexion with the vineyards of Burgundy and Switzerland, and the subsequent observation of Millardet, in 1882, that the use of the mixture had the effect of protecting the vines from mildew, followed by the definite recommendation of its employment for that purpose.

Butler reviews the work of Millardet, and the evolution of the preparation and use of Bordeaux mixture down to the present time. These researches indicate that not only is there a marked divergence of opinion regarding the composition of Bordeaux mixture, but that various authors are by no means agreed as to the chemical and physical attributes of this mixture, and as a consequence of the lack of exact knowledge of these, its toxic and other biologi al properties are very imperfectly understood. The author accordingly undertook the study of the physico-chemical properties, and repeated the greater part of the work done by others in this connexion.

Bordeaux mixtures are conveniently classed according to the amount of crystallized copper sulphate taken to complete the mixture, and also in accordance with the ratio between the crystallized copper sulphate and the lime used, reckoned as quicklime. Thus Bordeaux mixture may contain varying percentages of copper sulphate, from 0·25 per cent. to 2 or 3 per cent. being often employed. Similarly, the ratio between sulphate of copper and lime may range from a 5 : 1 to a 1 : 1 ratio, or even higher.

On mixing a solution of copper sulphate with calcium hydrate, the simplest reaction that can occur is the production of copper hydrate and calcium sulphate, but on experiment it is found that instead of simple copper hydrate being formed, the precipitate contains various basic copper sulphates. These have been accurately studied by Pickering*, who shows that with increasing quantities of calcium hydrate, the following basic salts are successively formed :—

$$4\,CuO.\,SO_3$$
$$5\,CuO.\,SO_3$$
$$10\,CuO.\,SO_3$$
$$10\,CuO.\,SO_3\;3\,Ca\,O.$$

These basic sulphates may be changed one into another by the addition of more cupric sulphate, or more calcium hydrate. As ordinarily prepared, when the mixture contains but a small excess of lime, the basic sulphate usually present is 10 CuO. SO_3,

*Chemistry of Bordeaux Mixture, *Journal Chemical Society*, (T.), 91, pt. 2, 1907.

but when a considerable excess of lime is used, the mixture contains more and more of the compound 10 CuO. SO_3 3 CaO, in proportion as the lime is increased.

An important point in the physical character of Bordeaux mixture is the extent to which the precipitated copper salt remains suspended in the liquid. This depends on the nature of the basic salts produced, some of these being dense and settling rapidly, others gelatinous and remaining long in suspension. The basic salts first formed, tend to change into other basic salts, or mixtures of these, dependent on the ratio of copper sulphate to lime employed. The position is, however, complicated by the fact that the gelatinous precipitates tend to crystallize into blue sphaerocrystals, causing a deterioration of the mixture. These sphaerocrystals settle rapidly, and are less effective as a fungicide. The circumstances affecting these changes were critically studied.

These sphaerocrystals are formed in mixtures having a ratio of copper sulphate to lime of less than 5 : 1, even when the amount of copper sulphate is as low as 0·25 per cent. They are not, however, formed in mixtures containing higher ratios of copper sulphate to lime, such as 6 : 1, and this even when the percentage of copper ranges between 0·5 and 2 per cent.

The point of complete deterioration may be determined in several ways, by observing the changes in colour, or by observing the rate at which the mixture settles. The author, however, devised the more accurate method of detecting the presence or absence of gelatinous magma, by placing a drop of the Bordeaux mixture on a microscope slide, rapidly drying and cooling it, after which a drop of fresh hydrogen sulphide solution is placed on the slide, when the presence or absence of gelatinous magma can be brought out by microscopic study, as it is blackened while the sphaerocrystals are but little, if at all, affected. The author states that, if great accuracy is required, the slide may be subjected to the action of gaseous hydrogen sulphide, which is without action on the sphaerocrystals

The first results recorded are to the effect that both increase of temperature and of concentration hasten the deterioration of Bordeaux mixture. Foreign substances exert some influence on the period of deterioration; magnesium carbonate, magnesium oxide, and ferrous sulphate retard deteriorations somewhat, and so do ammonium salts.

Various organic substances, such as peptone, glue, and cane sugar greatly retard the deterioration of Bordeaux mixture, the latter being particularly effective: invert sugar exerts a retarding influence, but leads to the reduction of the copper and its precipitation as cuprous oxide: similar reduction takes place when cane sugar is used, but much more slowly.

Increase of temperature is shown to hasten deterioration, the change taking place at 25° C. very much more rapidly than 9° C. The degree of concentration of the mixture influences the rate of deterioration in a somewhat irregular manner; weak mixtures containing 0·125 per cent. of copper sulphate deteriorate

very slowly, if at all; stronger mixtures deteriorate more quickly; but it would not appear from the data recorded that there is a definite connexion between the concentration and the rate of deterioration.

The proportion of calcic oxide used in relation to the copper sulphate influences the rate of deterioration. Mixtures in which the ratio of copper sulphate to lime is 1:1 deteriorate more rapidly than those in which the ratio is 1 : 0·5. It was first pointed out by the Duke of Bedford and Pickering that mixtures prepared with an excess of lime, as is commonly the case, deteriorate quickly. Two points of practical importance are thus brought out, namely that Bordeaux mixture should be prepared without excess of lime, or with only a small excess—a matter again referred to later,—and that the mixture should be used fresh.

Butler has carefully reviewed the information available concerning the weathering of Bordeaux mixture, the work of the Duke of Bedford and Pickering being particularly important in this connexion as affording the most complete study of the question. The latter show that the basic sulphate of copper, when acted on by carbon dioxide, should yield theoretically definite amounts of cupric sulphate; the basic salt 4 CuO. SO_3 should yield one-fourth, and the basic salt 10 CuO. SO_3 one tenth of its copper as soluble copper sulphate, on treatment with carbon dioxide. After treating Bordeaux mixture, the amount of soluble copper found is in some instances slightly in excess of the theoretical quantity, but in most cases, and particularly in the case of the ordinary Bordeaux mixture, it is less. These anomalies are explained by the Duke of Bedford and Pickering, by the suggestion, that in the case of the basic salt 4 CuO. SO_3, the greater solubility of copper is due to the solution of one of the basic copper carbonates produced, while the reduced solubility in the case of the more basic sulphates is due to side reactions between the calcic carbonate and the copper sulphate. Gimingham suggests that, when the excess of carbon dioxide is romoved, the copper sulphate is precipitated by the basic copper carbonate.

The greatest interest from the agricultural point of view, perhaps attaches to the author's summary of observation on the physical properties of Bordeaux mixture. In making this review, not only has the author had regard to the work of previous investigators, but he has checked these results by an extensive series of experiments.

He studies first the colours of the basic copper sulphates more particularly concerned with Bordeaux mixture problems, indicating the colour of the freshly prepared precipitates, and the colour they assume after standing for twenty-four hours, and argues from the changes that they probably indicate that one of the higher basic sulphates is always found first, no matter what the ratio in which the cupric sulphate and calcic oxide are brought together, the changes to a salt of lower or higher basicity only taking place after a lapse of time.

Much consideration is given to the question of the nature of the basic sulphate formed when different ratios of copper

sulphate and lime oxide are employed, and when these are used in different degrees of concentration. The relative rates at which these precipitates subside is also fully studied, and it is demonstrated that the method of preparation has no inconsiderable influence on the nature of the basic sulphates, or mixture of basic sulphates formed. Experimental evidence is given to show that an increase in temperature of the mixture tends to increase the rate of subsidence.

A very interesting and important part of the paper is that which deals with the effect of the method of mixing on the voluminousness of the precipitate formed. It is shown that there are nine ways in which the mixture of the liquids containing the copper sulphate and lime oxide can be affected, namely :

Method 1.	Method 2.	Method 3.
Strong lime to strong copper.	Strong lime to weak copper.	Weak lime to strong copper,
Method 4.	Method 5.	Method 6.
Lime to copper in equal strengths.	Lime and copper equal strengths poured together.	Copper to lime in equal strengths.
Method 7.	Method 8.	Method 9.
Weak copper to strong lime	Strong copper to weak lime.	Strong copper to strong lime.

Butler then proceeds to collate the information given by the various observers. With regard to the effects resulting from different methods of mixing, he says :—

' In consulting the literature I have found that of the nine methods given above, six are recommended by one or another of the authors consulted, the same author not always being consistent. In a few instances (10 per cent.), of the authors consulted, I find that two or three methods of preparation are equally recommended, either 5 and 6, or 4 and 5, or 4, 5 and 6. The recommendations are, however, only in one instance based on an examination of the rate of the precipitate formed when Bordeaux mixture is made according to the above schemes, and in this instance even, method 5 was not examined, despite the fact that it is the most highly and most generally recommended, 41 per cent. of the authors consulted having unqualifiedly recommended it, or mentioned it solely. For the method of making Bordeaux mixture so consistently advocated in the literature, i.e., method 5, there seems to be little or no experimental foundation. An examination of the literature in which experimental data is given, shows this very clearly. '

After reviewing the observations of other workers, the author undertakes a series of critical experiments to determine the relative rate of settlement of 1 per cent. Bordeaux mixture (1 : 1), prepared according to the nine different methods mentioned, compares the results obtained with those of other experimenters, and critically reviews their results.

His tabular résumé of the work of various authors on rate of settlement of Bordeaux mixtures is as follows:

SETTLEMENT (IN RELATIVE NUMBERS) AFTER ONE HOUR.

Ref. No.	Author.	Method. 1	2	3	4	5	6	7	8	9
A	Warren and Voorhees	242	64	..	...	100	..	..	100	...
B	Jones	400	115	..	30	100	30	...	100	...
C	Rogers ...	...	164	...	...	64	..	...	100	..
D	Duke of Bedford and Pickering	3,650	2,300		1,550	...	350	...	100	3,500
E	Hakins	...	100	..	100	100	100	...	100	...
F	The writer (Butler)	169	61	74	52	64	60	49	100	195

An interesting study is made of the different amounts of calcium oxide actually in solution at the time of preparation, in eight of the various methods of mixing, and as a consequence it is stated, the conclusion seems warranted that the amount of soluble calcic hydrate present when Bordeaux mixture is made, directly affects the nature of the basic sulphate or basic sulphates formed, and that to its greater or lesser preponderance the divers effects of the method of mixing are largely due. The conclusion appears warranted that the rate of settlement increases with the amount of soluble calcic hydrate present at the time of preparation of the mixture.

The next step was to study the effect of varying the percentage of copper sulphate in the mixture, the former experiments having been made on a mixture containing 1 per cent. The experiments demonstrate that the mixtures prepared with the larger amounts of copper sulphate—the experiments ranged from 0·125 to 4·0 per cent.—settle much less rapidly, and that to a greater extent than was anticipated. From this point of view comparatively strong mixtures are thus preferable in practice to weak ones.

The effect of varying the ratio between the quantities of cupric sulphate and calcic oxide when making mixtures of different concentrations was carefully studied. The experiments confirmed those of the Duke of Bedford and Pickering, to the effect that a mixture prepared with the ratio of copper sulphate to calcic oxide of 1 : 0·2, settles more slowly than mixtures

prepared with greater or lesser amounts of lime: this is the case whether the mixture contains ½-per cent., 1 per cent., or 2 per cent. of copper sulphate; and it is pointed out that increase in the rapidity of settling is connected with a decrease in the amount of the basic sulphate 10 CuO. SO_3 that is formed.

The effect of the temperature at which the mixture is prepared was carefully investigated, and it is shown that the precipitates that are produced when the mixture is made at temperatures above 20°C. are more dense and less gelatinous than those produced at lower temperatures; the mixture also deteriorates more rapidly at high temperatures than at low. These points are of interest to workers in the Tropics.

Consideration was given to the effect produced by stirring, regard being had both to delayed stirring after mixing, and to the degree of stirring. The general conclusion is arrived at that, in practice, no ill effects will result if Bordeaux mixture is thoroughly stirred only after the spray tank has been filled, that is to say, if stirring is delayed a few minutes after the actual mixing of the copper sulphate and lime. It is problematical whether prolonged stirring, that is stirring for more than fifteen or twenty seconds, is necessary; it is remarked that in any case the mixture will be subject to more or less continued agitation during the operation of spraying, so that the question has not much practical importance.

An important section of the paper is that dealing with the types of Bordeaux, their preparation, and properties. The types may be divided into three classes: acid, neutral, and alkaline or basic.

An acid Bordeaux mixture, which however in its chemical reaction is nearly neutral, is one in which the amount of lime used is as low as possible, consistent with the precipitation of the copper in the form of a basic sulphate. Such a mixture is that known as Woburn Bordeaux mixture, the use of which is recommended by the Duke of Bedford and Pickering, which is made by using copper sulphate and lime in the ratio 6 : 1, the lime being dissolved in the form of lime-water. In this mixture, the copper is doubtless present in the form of 10 CuO. SO_3. Care must be taken in making the acid mixture to ascertain that no solute copper sulphate exists in the solution. The ferro-cyanide reaction is recommended for this, the test by means of a piece of bright steel not being satisfactory.

The following brief summary of directions for preparing the three types of mixtures is convenient and useful :—

1. Acid Bordeaux mixture. Prepare 100 parts of 1 per cent. or 2 per cent. neutral Bordeaux mixture, and add to it 0·1 or 0·2 parts copper sulphate previously dissolved in 10 parts water.

2. Neutral Bordeaux mixture. Copper sulphate 1 part; milk of lime sufficient to produce alkalinity; water to 100 parts.

3. Basic Bordeaux mixture. Copper sulphate 1 part; quick-lime 0·5 to 1 part; water to 100 parts.

The use of 'acid' or 'neutral' mixtures is recommended; in these, if carefully prepared, the copper is present principally in the form of the basic sulphate 10 CuO. SO_3, while in alkaline mixtures this salt is present together with the compound 10 CuO. SO_3 3CaO, the latter probably predominating.

In preparing Bordeaux mixture for field work, the use of stock solutions is advised for facilitating the mixing, and it is stated that Bordeaux mixture can be prepared equally well by either of the following methods:—

Strong lime to weak copper	=	method	2
Lime to copper equal strengths	=	"	4
Weak lime to strong copper	=	"	3
Lime and copper equal strengths poured together	=	"	5
Weak copper to strong lime	=	"	7
Copper to lime equal strengths		"	6

SOME SUGAR FACTORY CALCULATIONS.

BY FRANCIS WATTS, C.M.G. D.Sc, F.I.C., F.C.S.,

Imperial Commissioner of Agriculture for the West Indies.

The altered conditions with regard to sugar production that have come about within the past few months are likely to revive the idea of providing additional central sugar factories in the West Indies, and renewed efforts will doubtless be made to attract capital, now that greater dependence is likely to be placed on the production of cane sugar in British colonies.

In inviting the co-operation of capitalists for this purpose, difficulty is often experienced in apportioning the share of charges, and of profits that may reasonably be allotted to the cane grower and to the capitalist, respectively.

A method of working that has proved satisfactory in certain cases, and may be recommended for wider adoption, is for the cane growers to supply the factory with canes under a contract, receiving in return a provisional payment for the canes delivered, followed by a payment of a share of the profits, and finally, as soon as the capital has been repaid, for the cane growers to receive paid up shares, whereby they directly participate in the ownership of the factory.

In contemplating such a proposal as is here outlined, the question at once arises as to the price that should be provisionally paid for the canes, and what share of the ultimate profits may be reasonably allocated to the cane grower, and to the capitalist.

The first thing that is evident is that the terms of the proposition vary with every change in the price of sugar; each party, therefore, is apprehensive lest the changes may place him at a disadvantage and, in consequence, desires to create in the bargain, such margins of safety as he thinks will protect his interests. The cumulative effect of these margins at different points is usually such as to frighten the several parties and to wreck the proposals.

As the outcome of some experience in this connexion, I have prepared a diagram, which indicates with considerable accuracy various phases in such propositions as are outlined above, and enables a concrete view of the position to be taken in each case in relation to the various prices of sugar.

The terms on which the diagram is based, are as follows :—

It is assumed that to erect and equip with moderate railway facilities modern factories capable of making amounts of sugar ranging from 5,000 to 10,000 tons of sugar in a season of about four months, will require an outlay, in the first case, of about £68,000, ranging to about £133,000 in the second, or at the rate of £13⅔ per ton of estimated output—a sum which in all ordinary cases may be regarded as fully ample.

Provision is made for paying to the shareholders interest at the rate of 5 per cent., and for accumulating a reserve fund, by the setting aside of a similar sum of 5 per cent., by which the capital may be repaid in about fifteen years, if the sinking fund can be invested at 5 per cent., or in about seventeen years if invested at 3 per cent.

It is estimatad that the canes can be hauled over the railway for moderate distances, and the sugar be manufactured and handled up to the point of shipment for £2 15s. per ton, plus the sum realized by the sale of the molasses, this additional amount being estimated at somewhere in the neighbourhood of 5s. or 6s. per ton of sugar produced, the cost of manufacture thus being taken at a total of about £3 per ton.

It is further assumed that a ton of 96° grey crystal sugar can be manufacturd from 9·1 tons of canes; this is based on experience gained with good average canes of the quality grown in Barbados and the Leeward Islands. For the conditions obtaining in British Guiana and Trinidad, this figure would require to be amended, as the average canes of those countries are somewhat less rich in sugar.

In the many discussions that have taken place, proposals for the provisional payment for canes have been made at various rates; usually these have taken the form of the suggestion to pay the value of a certain number of pounds of sugar for each 100lb. of canes supplied, the cane supplier, later, to receive a share of the profits of the factory. Commonly discussed terms have been 4½, 5, or 5½ lb. of sugar per 100 lb. of canes, and one-half of the profit of the factory after deducting the charges arising for working expenses, interest, and provision for sinking fund. These various propositions are dealt with in the diagram.

The length of each of the vertical lines of the diagram from bottom to top, corresponding with the various prices of sugar,

from £5 to £15 per ton, is taken to represent the value of the whole of the factory output at each of the given prices, that is, each vertical line represents 100 per cent. of the factory output, at each price under consideration. In the bottom part of the diagram a curve, A, has been drawn, which represents the amount of the factory output that would be required to effect the payment of 5 per cent. on the capital, which amount it is proposed to set aside for the sinking fund.

Above this curve is drawn another, marked B; this shows the amount of the produce that is required to provide the sum set aside for manufacturing the sugar, namely £2 15s. per ton (the proceeds of the sale of molasses to be used in addition, to meet manufacturing charges).

Above this there are drawn three curves, C, D, and E; these cut off amounts corresponding with, C, 4½ lb.; D, 5 lb.; and E, 5½ lb. of sugar, respectively, as the payment per 100 lb. of canes. These lines are to be used alternately, according to the proposition under consideration.

The height of these curves shows the proportion of the factory output that will be consumed to meet the charges for sinking fund, manufacture of sugar, and the purchase of canes, regard being had alternately to the curves C, or D, or E, according to the terms of the contract. The length of line remaining between the curve and the top of the diagram represents the proportion of the factory product available for interest on capital, and profit for division between capitalist and cane supplier.

From the top of the diagram, measuring downwards, is drawn the curve F. This represents the amount required to pay interest on capital, at the rate of 5 per cent The space between the curve F, and either of the curves C, D, or E, according to the contract adopted, represents the proportion of the factory's produce that is available as profit, and consequently for division between capitalist and cane supplier.

In order to illustrate how this may be divided, two lines, G and H, are drawn one, H, dividing the space between the curves C, and F into two equal portions. The length of the vertical lines from the curve C to the curve H, represents, for each price of sugar, the proportion of the factory's product that would be handed over as additional payment to the vendor of canes, who had sold on the basis of 4½ lb. sugar per 100 lb. of canes, plus half profits.

Similarly, the line G indicates the position, when the basis of trading is 5 lb. of sugar and half profits. Other curves may be readily drawn to indicate other divisions of profits; they have been omitted here, however, to avoid confusion from over crowding.

The diagram indicates plainly how the price of sugar affects the interests of both parties—the cane supplier and the factory owner. It shows that if a factory can be operated on the conditions laid down, and it is believed that a safe and reasonable basis has been taken for the calculations, then such a factory can pay its working expenses, together with an appropriation for sinking fund at the rate of 5 per cent. on its capital, and interest

to shareholders, also at the rate of 5 per cent., to a point where the price of sugar falls slightly below £7 per ton, when it purchases its canes on the basis of $4\frac{1}{2}$ ℔. of sugar per 100 ℔. of canes: or, it can pay at the rate of 5 ℔. and still meet its obligations until the price of sugar falls to £7 10s.; or if it pays $5\frac{1}{2}$ ℔., the critical point is reached when sugar sells at about £8 5s.

We are thus able to see at a glance, that the proposals to operate factories on the terms set out are perfectly safe, from the point of view of the investor down to prices for sugar as low, or lower, than any that are likely to be realized. A continuation of prices for a season or two in the neighbourhood of those mentioned, would lead to a general collapse of sugar growing in practically every sugar-producing country. Speaking generally, it may be taken that a sugar factory, in a country producing a good quality of canes, can safely afford to base its operations, on the payment to the cane growers of 5℔. of sugar per 100℔. of canes, together with half the profits of the factory.

The manner in which a fall in price affects the profits of a factory, by causing an increased proportion of the output to be taken up in paying manufacturing charges, and fixed charges such as those for interest and sinking fund, is readily appreciated from the rapid change in the curves A, B. and F. When sugar sells at £9 a ton, the collective effect of these charges is to take up $45\frac{1}{2}$ per cent. of the factory output, whereas at £12. the amount is $34\frac{1}{4}$, and at £15, only $27\frac{1}{2}$ per cent.

It will be clearly understood, that these results are calculated on the assumption that the factory receives a full and regular supply of canes. Any serious falling off in output increases the cost of manufacturing the sugar, and throws the burden of the fixed charges, such as those for interest and sinking fund, upon a diminished revenue It is therefore essential to success, that the factory should be assured of its cane supply, and it is necessary that the factory should be operated to its full capacity. In this connexion it will probably be found to be economically sound to keep the size and cost of the factory down to the anticipated size of the average crop, and to depend upon an extension of the grinding season for dealing with crops above the average.

One factor there is that cannot be taken into account in constructing such a diagram as this, that is drought. The occurrence of severe drought may reduce the cane supply in such a manner as to imperil the profits: the general nature of this risk can, however, be calculated to some extent for any given district; it is a risk which capitalist and planter alike have to face.

The diagram serves a double purpose. In the first instance it may be read as showing the distribution of the charges and profits of the factory as a whole, and this is the sense in which it has, so far, been considered. It may, however, be also used to indicate the proportion of the various items dealt with as charges per ton of sugar, the whole length of each vertical line being taken to represent a ton of sugar at each of the values given.

In dealing with the diagram, it is to be borne in mind that it represents relative and not concrete values, and that the money value of each vertical line increases in proportion as the price of sugar increases; the value of each division cut off by the horizontal lines increases by 6*d.* with each increase of £1 per ton in the value of sugar. The value of each division, in terms of money, corresponding with the various prices of sugar, is as follows:—

Value of sugar per ton.	Value of each division.	
£	s.	d.
8	4	0
9	4	6
10	5	0
11	5	6
12	6	0
13	6	6
14	7	0
15	7	6

These amounts may be read, per ton of sugar produced.

It may be useful to state here the several values of a ton of canes under the different conditions of payment and of price. They are as follows:—

Price of sugar per ton.	Value of canes per ton. 4½ lb. of sugar per 100 lb. of cane.		5 lb. of sugar per 100 lb. of cane.		5½ lb. of sugar per 100 lb. of cane.	
£	s.	d.	s.	d.	s.	d.
8	7	2½	8	0	8	9½
9	8	1½	9	0	9	10¾
10	9	0	10	0	11	0
11	9	10¾	11	0	12	1¾
12	10	9½	12	0	13	2½
13	11	8½	13	0	14	3½
14	12	7½	14	0	15	4½
15	13	6	15	0	16	6

It should be pointed out that in some contracts a clause is inserted, to the effect that in the event of the price of sugar being so low as to make the price of cane less than 10*s.* per ton, then a payment shall be made from profits, if these permit, of such an amount as will bring the price up to 10*s.* before any division of profits is made.

By the use of the diagram, it is possible to calculate the price that canes may be expected to realize when the division of profits is taken into account. Thus, taking the conditions when sugar sells at £10 a ton, and canes are delivered on the 4½ lb. basis, by measuring on the diagram, it will be found that the anticipated profit per ton of sugar falling to the share of the cane grower, that is, the amount indicated by the distance on the vertical line corresponding with £10 per ton, between the lines C and H, is equal to 8·6 divisions of the scale. Now each scale division at

£10 has a value of 5s., so that there is a sum of 18s. for division for each ton of sugar; but a ton of sugar requires 9·1 tons of canes, so that there is a sum of 1s. 11¾d. per ton of cane to be added to the first payment of 9s., making the estimated total payment 10s. 11¼d. per ton of cane.

If the calculation is made on the 5 lb. basis, it will be found that the estimated profit accruing to the cane supplier is equal to 2·7 scale divisions, or 13s. 6d. per ton of sugar, equal to 1ls. 5¼d. per ton of cane, making the total value of the canes 11s. 5¼d. per ton.

In this way, there is disclosed the effect of increasing the first payment on account of canes from 4½ to 5 lb.; there is an increase of 1s. per ton in the first payment, but the profit for division is 1s. 5¾d., whereas on the 4½ lb. basis, it is 1s. 11¼d. This effect is readily seen by mere inspection of the diagram.

By using a pair of dividers, it is easy to lay out upon the diagram the position indicated for other propositions not now shown. Thus the position that would result if other amounts than 4½ or 5 or 5½ lb. of sugar were paid for canes is revealed: the distance between the lines D and E, being equal to ½-lb. of sugar per 100 lb. of canes, serves to lay out the new position required. In this way, the results of paying such amounts as 6 or 7 lb. can be at once ascertained. In this way, it will be found that the payment of 6 lb. extinguishes all divisible profit when the price of sugar is £9 a ton, leaving only provision for interest and sinking fund; while 7 lb. absorbs all divisible profit up to the point when sugar sells at about £11 5s.

The effect of sharing profits in other ways than in equal moieties, as shown in the diagram, may be ascertained at once without troublesome calculations.

Similarly, calculations may be made as to the estimated profits of the capitalist. On measuring the length of the lines representing the capitalist's share of profits, it will be seen that on the 4½ lb. basis, he receives the equivalent of 4·8 divisions, and on the 5 lb. basis, 3·7 divisions. Comparing these with the length of the line representing 5 per cent., 2·7 divisions, it will be found that the profit is equal, in the first case, to 8·8 per cent, and in the second, to 6·8 per cent., to which must be added the 5 per cent. already paid, making the total estimated gain on the capital, 13·8 per cent., on the 4½ lb. basis, or 11·8 per cent., on the 5lb. basis.

With calculations readily made in this way, it is comparatively easy to ascertain quickly, and in a convincing manner, the effect of various proposals that may be put forward in discussing factory schemes, and for either party to convince himself of the fairness or safety to the scheme, of any proposal that may be made.

In conclusion, it may be added that at the end of a given period it is to be anticipated that the sinking fund will permit of the repayment of the original capital invested, so that charges for interest and sinking fund will no longer be necessary, and the profits of the participants will increase. It may be suggested however, that it would be well to allow of the allocation of a sum similar to the provision for sinking fund, in order to provide for

the renewal of machinery, which at the expiration of this time will be out of date, in some respects. The charge for interest will, however, disappear.

The question now arises, as to the equitable position of the cane suppliers and of the capitalists. If the contract has provided for the cane suppliers to receive shares in the factory, equal in number and value to the original shares so soon as the capital has been repaid, and if the original contracts as to cane supply are then allowed to stand, it will follow that the cane suppliers will then receive one-half of the profits falling to the capitalists' share, they having taken rank with the capitalists. The diagram enables the position thus created to be quickly grasped, and to permit it to be decided whether this arrangement is deemed equitable to all parties. Should other arrangements be suggested, their effects can also be determined at once by the use of the diagram.

EXPLANATION OF DIAGRAM.

Curve A. Sinking fund at the rate of 5 per cent. on capital; measured from base.

Curve B.—Cost of manufacture of sugar at the rate of £2 15s. per ton; measured from A.

Curve C.—Payment for canes on basis of 4½ lb. sugar per 100 lb. cane; measured from B.

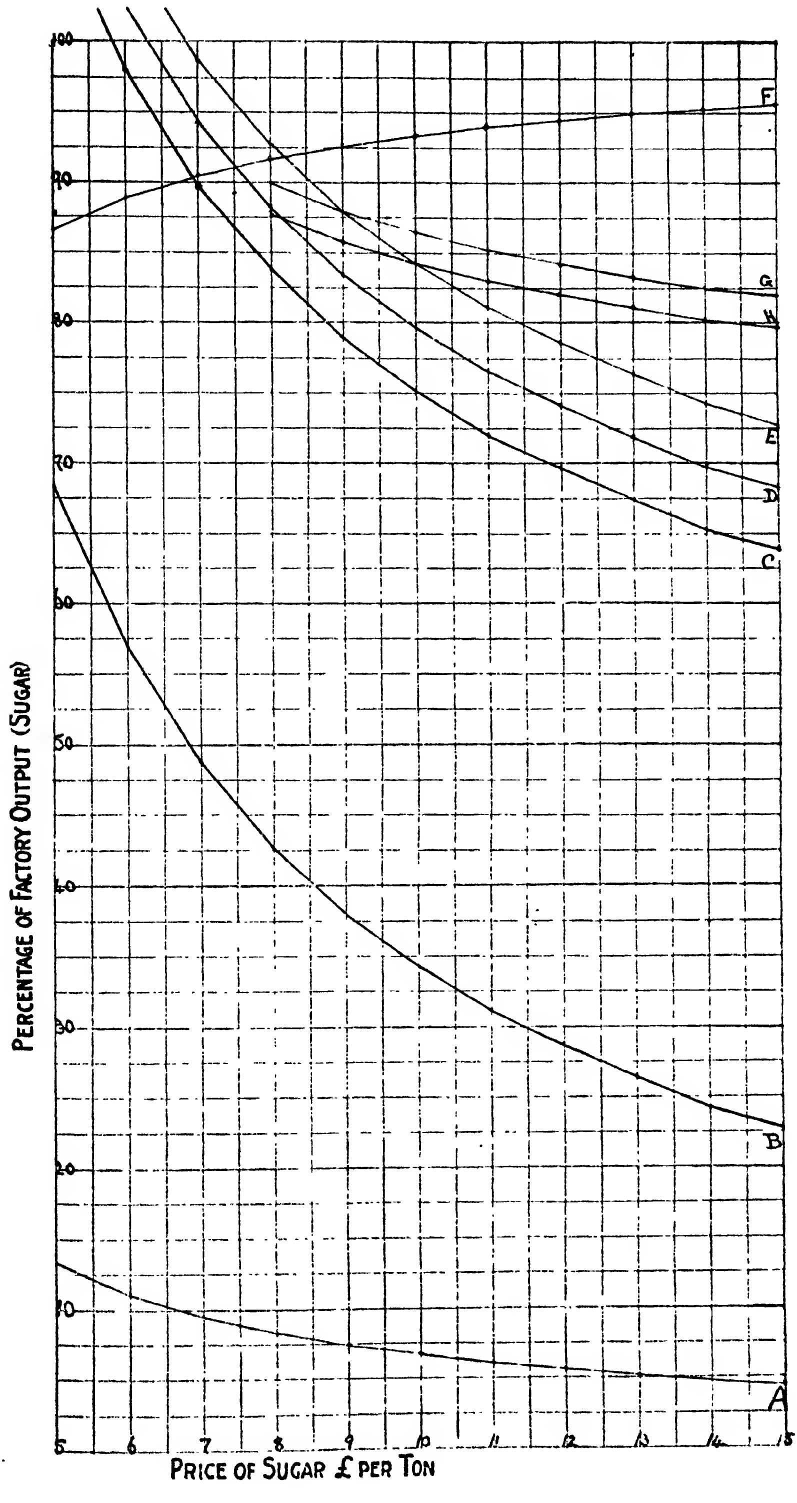
Curve D.—Payment for canes on basis of 5 lb. sugar per 100 lb. cane; measured from B.

Curve E.—Payment for canes on basis of 5½ lb. sugar per 100 lb. cane; measured from B.

Curve F.—Interest on capital at 5 per cent.; measured from top.

Curve G.—Half profits of factory, on basis of 5 lb. sugar per 100 lb cane: cane suppliers' half to be added to curve D capitalists' half to be added to curve F.

Curve H.—Half profits of factory on basis of 4½ lb. sugar per 100 lb. cane: cane suppliers' half to be added to curve C; capitalists' half to be added to curve F.


Percentage of Factory Output (Sugar)
Price of Sugar £ per Ton
F
G
H
E
D
C
B
A
100
90
80
70
60
50
40
30
20
10
5
6
7
8
9
10
11
12
13
14
15

THE SUGAR INDUSTRY IN CUBA.

BY NOËL DEERR.

The accompanying report on the Sugar Industry is reproduced from the *Louisiana Planter and Sugar Manufacturer* for December 12 and 19, 1914.

This report is of much interest both on account of the important position held by Cuba as a source of supply for the world's sugar markets, and of the high reputation of Mr. Deerr as an expert in sugar production.

According to a footnote* which appeared on the first page of this paper in the *Louisiana Planter*, the report was submitted to the Secretary of Agriculture, Havana.

CULTIVATION OF SUGAR IN CUBA.

The island of Cuba has rightly or wrongly earned the reputation of being the worst cultivated of all the cane-producing countries known, and its pre-eminent position as the largest and at the same time cheapest cane sugar producer in the worlds would seem to contradict this impression, at least as far as regards economy; and possibly the lack of cultivation may be the result of the natural selection of the procedure most suitable to local conditions; the main object of the producer is to make the maximum of profit, and if his maximum of profit is to be obtained with small return of raw material per acre, the producer cannot be blamed if his yields are not so high as those obtained in other districts where conditions are far removed from those in this island; this cheap production is all the more remarkable, when in addition to the raw yield per acre, the high price of labour is also considered. How widely different conditions in other sugar-producing countries may be, can best be seen by a comparison of Cuban conditions with those of Java and Hawaii, a comparison which of itself will be sufficient to show that methods applicable to one district, may be quite impossible when attempted in a second; the main difference between these districts are:—

Cuba: Production divided between older plantations long, in cultivation and large areas of very productive, virgin land.

Hawaii: Nearly all available land already in cultivation.

Java: Land planted to cane restricted by the Government, which decrees how much cane in each district shall be planted annually.

Cuba and Hawaii: Land under the control of the owners, and period of ratoonage at the will of the owner.

Java: Land leased from native owners, and confined to a yearly tenancy, making ratoonage impossible

Cuba and Hawaii: Restricted supply of labour receiving a high rate of wage, the supply in Cuba being less, and the rate of wage higher than in Hawaii.

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*This report was submitted to the Secretary of Agriculture, Havana, by Mr. Deerr.

Java : Dense native population, receiving a very low wage.

Cuba : Product sold with small protection.

Hawaii : Product up to the present sold under protection

Java : Product sold without protection.

Cuba : Close access to market, with small freight charges.

Hawaii : Long distance from main market, with high freight charges

Java : Market both close (British India), and at a distance.

Cuba : Crop produced almost entirely under natural conditions of rainfall.

Hawaii : Great part of crop produced in arid district, independent of rainfall.

Java : Irrigation used as an aid, but chiefly dependent upon natural rainfall.

It is the combination of these conditions, which are, I think, responsible for the extensive system of cultivation practised in Cuba, as opposed to the intensive system practised in Java and Hawaii, both of which districts produce much more sugar per acre than does Cuba. To point out more especially what I have in mind to point out, let us consider the maximum possible output of cane per acre as 'A + B + C + D' tons per acre. Now, I think it is almost self-evident, that the first unit of production, 'A' tons per acre, will cost less to produce than will the second unit of production of 'B' tons per acre, which will in turn cost less to produce than the third unit of 'C' tons per acre, and so on. As an example, let it be supposed that 20 tons of cane per acre can be produced at a cost of $1·50 per ton; that by increased cultivation, tillage, etc., 10 additional tons of cane per acre can be produced at a cost of $2·00 per ton, making in all a production of 30 tons per acre, at an average cost of $1·67 per ton. Now suppose this cane sell for $1·80 per ton; when 20 tons of cane are produced per acre, the cane which cost $30·00, will sell for $36·00, leaving a profit of $6·00; when 30 tons of cane are produced per acre, the cane which cost $50·00, will sell for $54·00, leaving a profit of only $4·00. But now, instead of the cane selling for only $1·80 per ton, let the price be $2·00; then with 20 tons per acre, the cane sells for $40·00, leaving a profit of $10·00 per acre; and also the 30 tons of cane which cost $50·00 to produce, will sell for $60·00, leaving a profit of $10·00. With cane selling at $2·20 per ton, the profit per acre when 20 tons are produced, is $14·00, when 30 tons are produced, the profit is $16·00. Now it is apparent from this argument, how a large production per acre may be attended with financial loss, and I believe that in this reasoning is to be found the cause of the low production of sugar per acre in Cuba, and at the same time the cause of the high production per acre which obtains in Hawaii, where the cheaper labour and, up till now, high selling price of sugar, have enabled relatively enormous quantities of more expensive cane to be produced at a profit per acre. The larger production in Java, where the stimulant of artificial high prices is wanting, is of course to be accounted for by the very cheap labour. I believe

then, that the present technically inefficient methods of cultivation in Cuba are due almost entirely to economic reasons, and that the cultivator is not altogether to blame in not adopting a more intensive system, and producing a larger return of raw material per acre of land. These considerations apply more particularly to normal market conditions, and not to such abnormal prices as exist now.

It is not, however, to be supposed that I am of the opinion that the methods of agriculture pursued generally in Cuba are the best possible. I have only tried to point out the reasons why imperfect methods, due to economic reasons, have survived as the fittest; there are many improvements which may be suggested, and which can best be considered by reviewing the regular Cuban practice as I have seen it in Cuba.

In the older lands where a routine quite different from that followed in the newer lands in the eastern part of the island prevails, as far as I have been able to judge, the preparation of the land for planting is well and thoroughly done, even when performed with the Cuban plough drawn by oxen; this I only mean to refer to the condition of tilth of the soil, for the Cuban plough does not, I believe, disturb more than the top 4 inches of soil, and leaves untouched the lower layers. In talking to cultivators and others interested in the cultivation of the cane, the objection to deeper ploughing is raised, in that it is believed that ploughing to any deeper depth will result in permanent injury to the soil, due to bringing to the surface a deleterious subsoil; though I have a very great respect for the experience accumulated by practical workers over many generations, I believe that on many soils in this island the danger of loss resulting therefrom is much less than is supposed. This remark of mine applies especially to the red soils, which seem to be of great depth, and I believe that ploughing to a depth of up to 12 inches would in a very marked degree increase the productibility of the soils, and give to them a new lease of life; on the other hand, there is a type of soil (black) which I have frequently seen overlying a very heavy clay, and this type is one in which it would be very undesirable to plough deep. In regard to the conditions in the eastern portion of the island, the methods there adopted in recently cleared forest land, seem to be the only ones practical, and here the problems of cultivation, as they exist in the western end of the island, will not arise for years.

It is the general Cuban practice to leave on the fields the trash or dry leaves of the cane from one year to another. This is a process which is not followed in any other cane-producing country, and it at once struck the writer as peculiar. I believe that the cause of this practice is to be found in economical conditions as already put forward, namely, that with the low price of sugar or high rate of labour, every process must produce not only an increase in cane, but an increase sufficient to pay for the increased expenditure, which in Cuba must be a larger increase than in other districts where either labour is cheaper, or the price of sugar higher. All the same, I do not believe that the Cuban practice of leaving the trash on the fields to rot, and to be ultimately absorbed into the soil, is one to be rashly condemned; it has been pointed out to me that this covering of trash prevents

evaporation of water from the soil, which in Cuba is a matter of very great importance, bearing in mind the long periods of drought which frequently occur.

In the Hawaiian Islands it has been the almost universal practice to burn off the trash ; conditions however are there very different ; on the irrigated plantations there is no question of conservation of the soil water, and in much of the rest of this district the rainfall is so plentiful that the question, too, is of minor importance; yet, however, there are not wanting experienced planters there who protest against the loss of much valuable matter ; it may be a coincidence, but for the crop of 1912-1913 in the Hawaiian Islands, the only plantation in a certain district which suffered from drought and obtained a normal yield, was one on which the trash had been systematically buried over a number of years, and I am inclined to attribute the long-continued fertility of many Cuban plantations to the practice of leaving the trash on the ground, as opposed to the system of burning it off. One objection to the Cuban practice of leaving the trash as a carpet on the land, is that it hinders the early growth of the ratoon crop, and the process advocated a number of years ago by Mr. Earle, namely, of collecting the trash into alternate rows, and cultivating in the bare row has much to recommend it. There is no doubt whatever but that this procedure will result in larger crops of cane, but the question at once arises, if the increase will pay for the labour required. Another trouble in this connexion is not only the price of labour, but its absence. The greatest benefit from a procedure such as that proposed by Mr. Earle will happen when the operations are done as early as possible, but on many plantations that I have visited during the grinding season, every available unit of labour is engaged in harvesting the standing crop. This system, recommended by Mr. Earle, is now actually in operation at Constancia (Cienfuegos), and when I had the privilege of visiting that plantation, the superiority of the cane so treated, to that left with the trash *in situ,* was plainly apparent.

This scarcity of labour introduced another difficulty into the question of cane cultivation in Cuba, which is connected with the manner of growth of the cane plant. After the cutting of one crop, the root system of the crop just harvested, dies, and eventually a new root system, absolutely independent of the former one, is formed. The proper time for cultural operation, when done with the view of opening up the soil, is before the formation of the new root system, since after this has formed, all cultural operations are attended with risk of injury to the root system ; however, with the scarcity of labour in Cuba, it is hard to see how to arrange for an early cultivation of the fields.

In another part of this report I have given an outline of the probabilities of the alcohol industry, using the molasses as the raw material. With this supply of power, there is the germ of a complete revolution in the agriculture of Cuba. With the scarcity and high price of labour, every means ought to be taken to increase the capacity of each unit of labour. There seems to be a possibility that with a cheap source of power, and the adoption of power-operated agricultural implements, a much cheaper and more efficient cultivation of the soil is possible in Cuba, and

I would suggest to you the advisability of liberal legislation which would encourage the development of alcohol as a source of power; not only would this give a means of increasing the output through a more thorough cultivation, but at the same time an increased value would be given to the largest by-product of the cane sugar industry.

IRRIGATION.

The writer has spent nine years in the Hawaiian Islands, where possibly one of the most highly organized irrigation systems of the world has gradually been developed, and where, under an intensive system of irrigation and heavy fertilization, yields of sugar, averaging over all the irrigated area, 14,000 ℔. per acre, and reaching on some favoured plantations to 18,000 ℔. per acre, are obtained. Conditions in the Hawaiian Islands are very different from those which obtain in Cuba, and in another part of this report I have summarized the salient differences. It does not at all follow that a system which has been successfully developed with regard to one set of local conditions, will have an equal measure of success when translated to another. The two salient differences between Hawaii and Cuba are the cheaper labour and higher price obtained for the product, both in favour of the former district, whereby more extensive and intensive processes may with advantage be followed.

Important differences between Hawaii and Cuba are:—

(1) The irrigated plantations in Hawaii are so far dependent on irrigation that no attempt to grow cane commercially would be made in its absence; although a certain amount of rain does fall on the irrigated plantations, the capital invested in irrigation works may be regarded as earning money all through the year. In Cuba cane can be economically grown at a reasonable profit in the absence of irrigation, and accordingly the interest on capital would be a more serious item than in Hawaii.

(2) A second difference is climatological, and is concerned with the distribution of rainfall. In the Hawaiian Islands what rain falls on the irrigated plantation, falls mainly in the winter months, and the summer months are usually dry. It is during the summer months that water is most needed. Here, however, the conditions in Cuba are precisely reversed—the winter months are dry, and it is during the summer months that the rainfall is heaviest.

The question of the distribution of rainfall in Cuba has been made a study of by Mr. J. T. Crawley, the Director of the Estacion Agronomica; he has pointed out that over a period of forty-nine years there has never been one year without a three-months' drought, and also during the forty-nine years more than half the rain has fallen in less than four months. This observation would point to a very possible more extended use of irrigation than is generally considered possible; but again, a second consideration has to be borne in mind, and one that continually recurs when considering Cuban conditions, and that is the shortage of labour.

These periods most frequently occur during the winter months, where in many cases the whole available labour supply is engaged in harvesting the crop. The application of water in irrigation is one which requires a larger supply of labour, and it is problematical if many plantations would be able to find the supply during the winter months when the benefit from irrigation would be most; for example, one unit of labour can take care of, on an average, 1 acre of land a day. If only a two-weekly irrigation were attempted for 30 *caballerias* (or per 1,000 acres), seventy units of labour would be required, or two 1·3 units per *caballeria*, and I doubt if there are many places in Cuba which have so large a supply of labour available. Now however, let it be granted that these difficulties are not too great to prevent the application of irrigation; it remains to be determined if, with the low price of sugar and high rate of labour, there is a prospect of financial success. Now in Hawaii it has been found that the application of water with efficient, experienced labour, costs 60 c. per application per acre. The Japanese labour in Hawaii is extremely efficient, and with the higher cost of wage prevailing here, I think it is extremely improbable if water could be applied at less than $1·00 per acre per application, and from figures that have been given me from two places in this island where irrigation is under trial, the cost is greater. A very great advantage in favour of irrigation in Cuba is the low lift, which will nearly always be found all that is necessary; let the average lift be 40 feet, and let an irrigation of 1 acre require water equivalent to 4 inches of rain per acre, to be raised by pump; this allowance of 4 inches covers leakage, seepage, and all losses In Hawaii the lowest recorded figure of expense for lifting water, including interest, depreciation, fuel and labour, is 7·5 c. per million foot-gallons. The average is 9·0 c. These figures refer to plants of great size, since the lift is sometimes as much as 600 feet: the Cuban plants, in all probability, would be smaller, as the lift will be *less*. Let it cost in Cuba 10 c. per million foot-gallons; water equivalent to 4 inches of rain per acre, lifted 40 feet, will be approximately 4,000,000 foot-gallons, which will probably cost to elevate, 40 c. As the labour in application was estimated at $1·00 per acre, the cost of each irrigation of an acre of land in Cuba may be estimated at $1·10. There seems to be a possibility that irrigation might be economical even at the figure, but what has to be determined is the increase in tonnage per acre over and above the average, without irrigation, which can be obtained for this expense. Endless estimates could be made, showing a profit or loss dependent on the initial data taken; at present data are lacking to determine what increased yields will be obtained under Cuban conditions, and until this is known, it is impossible to say whether irrigation will be an economic success or not. At Constancia (Cienfuegos), belonging to the Cuban-American Sugar Company, there is now sufficient land under irrigation to settle definitely in the course of a few years the possibility of irrigation in Cuba. Once it is settled, with the combination of high rate of wage for labour and low price of sugar, the possibilities of irrigation in Cuba are immense. There seems evidence that the whole of the red lands overlying a limestone formation can be placed under irrigation from the subterranean sources with a lift not exceeding 40 feet;

the fertility of these lands is known to be great; they are known to respond readily to fertilization; they are possessed of a most efficient natural drainage, and are of a contour and slope which seem almost as if they had been made with a view to irrigation.

In addition to irrigation with water elevated from subterranean sources, I would call your attention to the possibilities lying in certain of the rivers of Cuba. I am informed that the Rio Cauto, in its upper reaches, is quite beyond the tidal influence, and here there is a supply of water many times over and above what would be required; in the Trinidad Valley there seems to be beyond question an opportunity for irrigation with an abundant supply of water, the flow of which during a period of drought, I roughly estimated to be of the order of 100,000,000 gallons daily. Cuba is a large country, and there are doubtless instances of other rivers the flow of which could be utilized.

Fertilization.

In dealing with the question of the fertilization of the cane in Cuba, a sharp line must be drawn between the older plantations in the western end of the island, and the more recently opened lands in the east. The planters whom I have met from the eastern half of the island are uniformly of the opinion that at present there is no need of fertilization in this district; this opinion is not based on experience or any knowledge of what increase might be expected from a fertilizer, but is rather an expression of conditions, namely, that the capacity of the available land is so much in excess of what the mills can grind, that there is no necessity of increasing the intensity of this output per acre. In the western part of the island where competition for cane is keener, and where the returns per acre are less, fertilization is beginning to assume an important position in the economy of sugar plantations. This is so much recognized that extensive and ably conducted experiments are now being carried on at Constancia (Cienfuegos), and at Tinguaro, at Soledad (Cienfuegos), and at various other places which I have visited. In all these places which I have visited there is a general concensus of opinion, that fertilization is effective only on the red lands, and that the black soils do not respond. Now generally in all other countries where systematic experiments have been made in fertilization of cane, there has invariably been found a response, and I do not think it likely that this lack of response is due to the fertilizer, or that some special mixture is required to act as a charm on the black soils, but I think rather that there is present some peculiar condition which fixes the maximum crop possible, beyond which it is impossible to go; this condition, if it exists, is merely an exposition of the law of minima.

As regards fertilization of the cane in general, I do not think I can do better than give a brief review of the position of cane fertilization as has been experimentally worked out, chiefly in Java, Hawaii, British Guiana, and the British West Indies.

'(a) The main result of all these experiments is that the returns of cane per acre are largely governed by the supply of readily available nitrogen given at an early period of the plants' growth.' These are, as nearly as I can remember, the very

words used by Harrison to express the results of over twenty-five years' experimental work. As regards the source of nitrogen, his experiments, conducted almost exclusively on heavy clay alluvial soils of andesite formations, have pointed to sulphate of ammonia as being the most efficient form of nitrogen, in preference to nitrate of soda or any form of slow-acting nitrogenous fertilizer, such as tankage or blood. Generally in British Guiana, benefit has not been found from the use of potash or phosphate fertilizer, and Harrison believes that annually sufficient of these elements are rendered available by cultural operations, as under the normal climatic conditions that the cane can absorb.

In Java, too, where also the cane lands are chiefly heavy clay, also of an andesite formation, and where conditions have such similarity to those found in British Guiana, sulphate of ammonia alone has been found to be the most efficient form of nitrogen, and also neither phosphate nor potash is used. In Java, however, cane nearly always succeeds rice as a crop, and it is claimed that the silt deposited from the water used in growing rice, adds sufficient plant food for the needs of the next crop.

In Hawaii somewhat different results have been obtained the predominant effect of readily available nitrogen has been generally well recognized, but an added benefit is invariably found with a complete fertilizer containing both potash and phosphates However, conditions in Hawaii are unique, in that, owing to the intensive irregation pursued there, the fertilizer applied always has an opportunity to act in its maximum efficiency. At present in that district a fertilizer is being used, containing 12 per cent. nitrogen, 5 per cent. potash, and 5 phosphoric acid, with greater success than previous mixtures containing less nitrogen and more minerals. There is another point of interest to Cuba, and which experiments conducted in Hawaii have brought out, and that is that a soil naturally fertile will respond in greater degree to the application of fertilizer than will a soil not so naturally fertile; in this way fertilization may be regarded not so much as a means to renovate exhausted soils, but as a means of further increasing the profits to be obtained from soils of a higher class.

The experimental observation that the yield of cane is governed by the presence of readily available nitrogen applied at an early period of the plant's growth, is quite in accordance with the method of growth of the cane; after cutting of one crop, the mother stool underground forms short, woody rhizomes containing a large number of eyes. The presence of readily available nitrogen has been found to stimulate the formation and growth of these eyes into cane, or in other words, to promote a vigorous suckering. There is another point in connexion with cane fertilization which has a distinct bearing on Cuban conditions. I have already mentioned that in Hawaii, it has been found that the most fertile soils respond most to fertilization; now granted that the application of readily available nitrogen promotes a vigorous suckering at this early stage, it is unreasonable to suppose that the soil conditions have any effect on the number of suckers formed, but the subsequent development of these suckers will be controlled by the conditions they meet with afterwards; and granted that an equal number

of suckers are formed in each case, the largest crop of cane will result when the later conditions are most favourable. This argument naturally leads to a second, namely, that fertilization alone will not have the most pronounced benefit. It is fertlliza-tion in combination with cultivation, good soil condition and water that will give the greatest benefit. Fertilization on a soil which for some reason cannot support a heavy crop, is so much money wasted. Soil conditions are within the control of the producer, climatic conditions and rainfall are not. In seasons like the one just past, fertilizer applied in say, May, in anticipation of the usual seasonal rains, which this year have failed to materialize, has not had an opportunity to afford a benefit. With irrigation, fertilizer can be applied without fear of its effects being lost, owing to unfavourable season, and this combination is perhaps one of the strongest arguments in favour of irrigation wherever it is possible to practice it.

In the preceding pages I have very imperfectly discussed some aspects of cultivation, irrigation, and fertilization: they apply especially to Cuban conditions: the three phases however ought to be considered as connected; good cultivation will give the best response only in combination with a bountiful supply of plant food and water, and the crop will be determined, not by the factor which is most efficient, but by that which is least efficient; and to obtain the greatest return from the fertilization, the other two factors must also be present in efficient condition. There is one other point in connexion with fertilization of the cane to which I may refer; heavily fertilized cane is not less sweet than is cane which has not been fertilized; fertilized cane, however, takes a longer time to become ripe than does cane which has not been fertilized, due to the heavier crop and less access of light and air. Further, a late fertilization results in the formation of new shoots which will reach the mill in a state of immaturity. This phase of fertilization is of course directly connected with the necessity of early application of fertilizer.

Very closely connected with the fertilization of the cane is the process of green manuring; the whole theory and practice of this process was exposed by Mr F. B. Cruz in a publication issued in 1906, by the Estacion Central Agronomica, but so far as I can judge, very little green manuring has been attempted in Cuba; indeed, the only places where it is becoming a part of the routine, are, I believe, on the Tinguaro, Nueva Luisa, and Constancia properties of the Cuban American Company. I believe that the general adoption of this system, especially on the lands in the western half of the island, would be attended with great benefit, and that this system would go far towards renewing the vitality of a number of worn-out lands from which now only two or three remunerative crops can be obtained from one planting. It was the writer's good fortune to spend two years in the island of Mauritius, where the system of green manuring has been practised for quite sixty years, and where it is considered an integral part of the routine of every well-conducted plantation; I have not statistics from which to quote, but I know that the tendency in that island, where the plantations are equally old with those in Cuba, is towards an increase in the return per acre, and this increase I am inclined in great part

to attribute to the rotation introduced every fourth or fifth year by the leguminous crop.

There is another point in connexion with fertilization which calls for notice; Cuba is to a great extent a country of limestone formation, and the soils generally contain large quantities of carbonate of lime; there are, however, soils which although well supplied with this material, respond notably to dressings of lime, and in this category might be included the heavy black clays, examples of which are of frequent occurrence in Cuba; liming of these soils may be expected to produce a 'mellower' soil, more easily worked, draining better, and responding more readily to fertilization. I do not, however, wish to recommend wholesale liming to owners and cultivators of such soils, but I believe that there is a *prima facie* case for experimentation in this direction. In discussing the question of cane fertilization in Cuba, I have merely attempted to indicate the general principles which have been established; I do not attempt to give specific formulas to suit Cuban conditions; I do not even think that it is possible to do so, and I am of the opinion that it is foolish to try to do so. In actual field work on the large scale, the one secure method is experimentation; a knowledge of the principles of fertilization is sufficient to restrict the scope of the experiments within reasonable limits, and I believe that every grower of cane on a large scale would do well carefully to experiment with fertilizers, to find out for himself from his own observation what combination and what quantities give the best results. In fact, to put the question he requires answered to the soil itself, and let the soil answer it.

Cane Varieties in Cuba.

Whereas nearly all other cane-sugar producing countries have for many years past devoted much time and money to either the importation of varieties, or to the creation of new varieties by means of seminal variation, very little work in this direction has been attempted in Cuba, and the cane fields of Cuba produce almost only one variety, known here as the Crystalina. I gather that other varieties have, from time to time, been introduced and grown in competition with this variety, which up to the present has survived as the variety most suited to Cuban conditions. This cane, which is one of the established commercial varieties, is, I believe, eminently adapted to Cuban conditions, as it bears the reputation of succeeding with a minimum of care, and under conditions where other varieties would fail. Nevertheless, I am altogether opposed to seeing but one variety of cane in any district, particularly in so large a district as Cuba, where failure of the one and only variety would mean a most serious loss. The history of cane in other countries contains more than one instance of a wholesale breaking down of one particular variety, and the dependence of the Cuban industry on one variety, is a source of danger, even though this one variety is the one most suited to Cuban conditions.

A second point connected with the matter of varieties is that it has often been observed that land planted to one variety shows a falling off in yield, a falling-off which frequently disappears on the planting of another variety.

The benefit which can accrue to a sugar industry from ntroduction of new varieties, is best exemplified by the experience of Java, where without doubt the most systematic work in seminal variation of the cane has been done. A number of years ago an extraordinary stimulus was given to this work by a sudden disease of the one main variety planted there. As a result of work in a sense forced upon the Java planters, a number of varieties superior to the older established ones, are now the standard varieties in Java. A most interesting phase of the work there has been the selection of varieties which mature at different seasons of the year, so that the mill is always in the position of grinding ripe cane, the value of which is very great.

I believe that any reasonable sums appropriated to be used for work done towards the creation of seminal varieties, will be money well expended, although before results are obtained, up to fifteen or twenty years may be spent.

When writing that little or no work has been done in Cuba in this direction, I must except the private work done at Soledad (Cienfuegos) by Mr. R. M. Gray, and carried on at the expense of Mr. E. F. Atkins. Though necessarily small in scope, I believe that the work done there is equal in scientific merit to that done anywhere else. Naturally it is only the individual who has organized this work at his own expense, who has a right to its benefit. Work of this nature is so important, however, to the community as a whole, that I believe it should be undertaken by the government, or by a combination embracing the whole of the planting industries.

The Status of Cuban Factories.

The writer's previous experience with the cane-sugar industry has been in districts where conditions, the reverse of those in Cuba, obtain. In the highly efficient and highly organized industry in Hawaii, the limit of the annual production of raw material has nearly been reached, so that economy in the cost of production is here to be sought, mainly by increased efficiency in the factories, and in the extracting from the cane the highest possible amount of sugar. In Cuba a condition which I consider unsound has arisen, owing to the facilities for the production of cheap cane, especially in the newly opened lands on the eastern portion of the island. This condition, which is of very great interest, and importance, has to my mind led to an important state of affairs, which I will illustrate to you from one of a number of examples which have come to my notice. Let us take the case of a mill situated in the eastern portion of the island, which is able to buy cane at 4½ per cent. ; let the price of sugar be ·02c. per lb., so that the 90 lb. of sugar paid per ton of cane, represents a money payment of $1·80 per ton of cane. Let the transportation expense to the central be 70c. per ton of cane, making the cost of cane as delivered at the central $2·50 per ton. Let the cost of manufacture, packages, freight, etc., be taken at $8·00 per ton ; let the period available for grinding be 150 days. The factory wishes to know what quantity of cane to grind in order to secure the maximum of profit. At this point a difficulty arises, since the connexion between capacity and

extraction cannot be exactly stated. However, the following scheme will serve to express the condition to which I wish to draw your attention. Assume that when the quantity of cane ground daily is 4,000 tons, a rendement of 11 per cent. is obtained; when 3,800 tons are ground, the rendement is 11·12 per cent.; when 3,600 tons are ground, the rendement is 11·24; when 3,400 tons are ground, the rendement is 11·36; when 3,200 tons are ground, the rendement is 11·48; and when 3,000 tons are ground, the rendement is 11·60. With these figures it is possible to construct a table showing how the profits vary with different capacity and rendement. This table for this one particular case is given below:—

Tons cane per day.	Tons cane per season 150 days.	Rendement per cent. on cane.	Tons sugar produced.	Cost cane at $2·50 per ton.	Cost of manufacture at $8 per ton of sugar.	Total cost cane and manufacture.	Value of product at $40 per ton.	Profit.
				$	$	$	$	$
4,000	600,000	11·00	66,000	1,500,000	528,000	2,028,000	2,640,000	612,000
3,800	570,000	11·12	63,384	1,425,000	507,072	1,932,072	2,535,360	603,288
3,600	540,000	11·24	60,696	1,350,000	485 368	1.835,568	2,427,840	592,272
3,400	510,000	11·36	57,936	1,275,000	463,488	1,738,488	2,317,440	578,952
3,200	480,000	11·48	55,104	1,200,000	440,832	1,640,832	2,204,160	564,328
3,000	450,000	11·60	52,200	1,125,000	417,600	1,542,600	2,088,000	545,400

Inspection of this table shows that with the data accepted, that is to say, with cheap cane, a condition may exist in which it is expedient to sacrifice efficiency to capacity.

Now, however, in place of cane being purchased at 4½ per cent., let the price be 6 per cent., all other conditions remaining the same; in this case the cost of cane delivered at the mill is $3·10, and the following table is capable of construction, which shows an increasing profit as capacity is increased:—

Tons cane per day.	Tons cane per season 150 days.	Rendement per cent. on cane.	Tons sugar produced.	Cost cane at $3·10 per ton	Cost of manufacture at $8 per ton.	Total cost cane and manufacture.	Value of product at $40 per ton.	Profit.
				$	$	$	$	$
4,000	600,000	11·00	66,000	1,860,000	528 000	2,388,000	2,640,000	252,000
3,800	570,000	11·12	63,384	1,767,000	507,072	2,274,072	2,535,360	261,288
3,600	540,000	11·24	60,696	1,674,000	485,568	2,159,568	2,427,840	268.272
3,400	510,000	11·36	57,936	1,581,000	463,488	2,044,488	2,317,440	272,952
3,200	480,000	11·48	55,104	1,488,000	440,832	1,928,832	2,204,160	275,328
3,000	450,000	11·60	52,200	1,395,000	417,600	1,812,600	2,088,000	275,400

It is easy to see how an endless number of more or less hypothetical cases may be constructed, since the variants to be introduced, and which control the final result, are so many, including therein price of sugar, percentage paid for cane, cost of transportation of cane, manufacturing expenses, etc.; but generally all the calculations I have made on this very important point lead to the conclusion that in certain cases, with very cheap cane, greater profits may be made by this sacrifice, as an example of ill-advised opportunism, and of extremely short-sighted financial economy, which I will illustrate by practical example, not referring to any one mill, but containing the embryo of conditions which may easily be duplicated:

A central is able to buy cane at 4½ per cent., and makes the maximum of profit when worked to the capacity of 4,000 tons of cane per day, and makes in 150 days a net profit of $500,000, and obtains a rendement of 11 per cent. By increasing the milling plant 50 per cent. at an expense of $100,000, the rendement is increased to 11·5. In 150 days' grinding this represents an increased output of 3,000 tons, which with sugar at only $40 per ton, should, at the lowest, net $30 per ton, or in all $90,000, representing a profit of 90 per cent. on invested capital; this is not merely a hypothetical case, but in studying local conditions in Cuba during the last six months, I have encountered several instances where such a state of affairs holds. In a discussion I had with a certain gentleman who is a great advocate of capacity, and who asked me my advice on this matter, the following point was particularly raised: 'It is admitted by you that under the present conditions prevailing, my factory makes the maximum of profit when efficiency is sacrificed to capacity; you advise me to install machinery to increase the efficiency; this machinery will at the same time be equally efficient in increasing the capacity; why should I not again work at the same relative efficiency as before, and again obtain the maximum of profit at a sacrifice of efficiency to capacity?' The reply to such an argument would be to again increase the plant until it was capable of again dealing with the absolute maximum of cane available. Further, such a scheme of indefinite increase of capacity would soon reach its limits, since increases of capacity would imply a larger area over which cane would have to be hauled, increasing the expense of raw material; and secondly, the competition between factories adopting such an indefinite increase in capacity would very soon cause a competition by increasing the price of cane, necessitating a policy of maximum efficiency in the centrals which purchased it. A further point worth while calling attention to is that every increase in rendement over and above any arbitrary standard is mostly profit, and when considered as a percentage on the profits already made, reaches very high figures; for instance, the division of costs of production of a mill worked for capacity rather than efficiency, may reasonably be: cost of cane and freight, 6·25 per cent., manufacturing expenses, packages, and all other charges, 3·50 per cent. on cane, in all 9·75 per cent. on cane. If the rendement is 11 per cent., there is left 1·25 per cent. sugar on cane as profit. If the efficiency of the factory is increased so that the rendement is 11·5 per cent., the profit is now represented

by 1·75 per cent. sugar on cane, an increase on the original profit of 40 per cent.

There is yet another point connecting the economic well-being of this island and a high standard of efficiency in the centrals, which is perhaps the most important of all; any increase in the efficiency of the factories will enable a high price to be paid to the original producer of raw material, which increase will be to him mainly all profit; in this way an increased efficiency in the factories should result in settling on the land an industrious and satisfied agricultural community with which the future of the cane-sugar industry in Cuba is necessarily connected. At the moment of writing there are prospects of relatively very great profits to be made from sugar; I believe that if these profits be at least in part used to place the factories of Cuba in the state of maximum efficiency, that this efficiency, combined with the many natural advantages possessed already, should assure the future of the industry for many years to come.

Of the 178 centrals operating in Cuba, the writer has visited upwards of thirty, including in that number some of the very oldest and some of the most recent factories; allowing that this number is sufficient to enable him to form a rational opinion of the conditions on the manufacturing side, he would offer you the following criticism in additional to what he has already had to say on the subject of capacity and efficiency; these criticisms will be mainly a comparison of Hawaiian and Cuban conditions.

MILLING.

The quality of mill work in general in Cuba does not reach the high standard to which the writer has been accustomed in Hawaiian experience; this is due to some extent to the larger capacity demanded from milling plants in Cuba. In Hawaii a 14-roller, 78-inch mill is reckoned to have a capacity of 65 tons of cane per hour; in Cuba I believe I am not wrong in stating that a 14-roller, 84-inch mill would be considered as capable of dealing with 85 tons of cane per hour; the difference in capacity is, however, not so great as at first sight appears, for the Hawaiian cane contains at least 10 per cent. more fibre than does the Cuban cane, and taking into account the larger size of the standard Cuban mill, the average of Cuban over Hawaiian mills would be of the order of 10 per cent. During the last few years the efforts in Hawaii to obtain efficiency at the milling plant have been attended with great success, and for the crop just finished the average extraction there is of the order of 95 per cent.; that is to say, the mills have extracted 95 per cent. of the sugar in the cane; I have no complete statistics of the work in Cuban mills, but of twenty returns to which I have had access, only two reached as high as 94 per cent.; six have an extraction lying between 92 per cent. and 93 per cent.; seven between 91 and 92 per cent.: two between 90 and 91 per cent., and three betwen 88 and 89 per cent. If these twenty mills be taken as typical of the average, and they include some of the most recent as well as some of the older plants, I believe I am not exaggerating when I estimate the average extraction in Cuban mills as 91-92 per cent. The value of the sugar thus lost, most of which could be saved at relatively

small expense, is very great, and the sugar thus lost by inefficient milling, if extracted, will represent nearly all profit. There are a great number of mills in Cuba where the capital invested in bringing the milling plant up to the limit of maximum efficiency would earn not less than 50 per cent. interest, and I have seen cases where the extra profits would pay for the investment in one year. Take, for example, a plant which I have actually seen—a crusher and three independent 3-roller units, not one of which was less than thirty years old; this mill ground cane which produced 20,000 tons of sugar; the extraction of this train, which formed one of the two trains the factory possessed, was 80 per cent.; with a capital expenditure of $120,000, a train could be installed which would have brought the extraction up to 95 per cent. or an increase of 10·4 per cent.; allowing that this extra extraction has not so great a sugar value as that already obtained, let it be taken that only 9 per cent. more sugar will be shipped, which will amount to 1,800 tons; with sugar selling at $40 per ton, it is justifiable to take that this extra amount of sugar will net as clear profit $30 per ton, or in all, $54,000—a very reasonable interest on an investment of $120,000. This is not an exaggerated case, but I could mention three factories where such a condition actually exists. In this connexion, I am prepared to express the opinion that the truly economic milling plant consists of a crusher and 15-roller mill, worked with a dilution such that the weight of mixed juice approximates to that of the cane, and obtaining an extraction of not less than 96-97 per cent.

The second main item in Cuban factories which calls for attention is the question of fuel; a very large number of Cuban factories burn very considerable quantities of wood and coal. In one factory I visited, the quantity of wood burnt was over 7 per cent. on the weight of the cane, and I gather that 3 per cent. of the cane is no uncommon figure; that Cuban factories should have difficulty with fuel is partly accounted for by the low percentage of fibre in the Crystalina cane, which forms the staple variety in Cuba, but if a comparison be made with Hawaiian conditions, where fibre in cane is higher, and where very little fuel is burned, it must be remembered that the work done there in the way of evaporation by this larger quantity of fibre, is also much greater. The position I am committed to is that, fuel, other than that afforded by the bagasse, is quite unnecessary in a well-designed and well-operated plant; on the other hand, with a heating surface in the boilers insufficient to permit of the generation of the requisite quantity of steam, with triple effect evaporation, with a multitude of individual motors, larger quantities of extra fuel may be necessary, and these conditions are frequently encountered in Cuban sugar houses. It is my intention, however, to call the attention of Cuban factory owners particularly to the extension of the system of multiple effect evaporation introduced into, and completely adopted by, the beet sugar industry, whereby the heating of the juices, and the operation of the vacuum pans is performed at double effect with great economy of fuel. It is not my intention to give in this report a technical description of this system, which is amply and completely described with reference

to cane-sugar houses, in a recently issued book: *Evaporation in the Cane and Beet Sugar Factory*, Koppeschaar. I wish, however, to point out that the adoption of this system will not only allow a typical Cuban factory to be operated with its present extraction without extra fuel, but will even permit of a considerably greater dilution, also without extra fuel. This system is already in operation in the Providencia mill, and is being installed for the coming season at "Soledad" (Cienfuegos); it is a matter of routine in Javan factories, and is being rapidly extended in Hawaii.

A third point to which I wish to draw attention is that of the keeping qualities of Cuban sugar; I believe very large sums are lost annually through a fall in polarization of the sugar on storage. The cause of this fall is the infection of the sugars with certain micro organisms. I have already addressed you a memorandum on the technical side of this question, in which I have indicated the methods by means of which this serious loss may be prevented, or mitigated.

There are two more points in connexion with sugar manufacturing in Cuba, of considerable interest, and which I refer to in the following sections.

THE MOLASSES PROBLEM IN CUBA.

Connected intimately with the well-being of the cane-sugar industry in Cuba is the molasses problem. At the present moment the molasses production in the 178 factories in Cuba is sold at rates varying from $2\frac{1}{4}$ to 4d. per gallon, and this may, on an average, be estimated to give the sellers a profit of one cent per gallon. I do not think this profit is reasonable, and I particularly wish to place before you the facts as to the molasses annually produced in Cuba.

For the crop of 1913-14, the sugar production of Cuba was very nearly 2,600,000; at a low estimate this must have produced 40 gallons of molasses per ton of sugar, or in all, 100,000,000 gallons of molasses. With the most modern processes of fermenting and distillation, these 100,000,000 gallons of molasses could have produced 40,000,000 gallons of commercial alcohol; in actual practice at the present time, as a source of power, alcohol is worth, bulk for bulk, 60 per cent. of gasoline; these 40,000,000 gallons of alcohol would thus be equivalent to 24,000,000 gallons of gasoline; worth 36c. per gallon, and in all $8,640,000. This would give to alcohol a value of 23c. per gallon, and enable it to compete with gasoline.

In addition to the sugar in the molasses, a very great proportion of the potash removed from soil by the crop of cane is to be found in the molasses. I have not available any analysis in Cuban molasses, showing the percentage of potash, but in all probability this will not be below 3 per cent. The 100,000,000 gallons produced for the crop of 1913-14, in Cuba, will weigh in all 600,000 tons, so that this molasses will contain 18,000 tons of potash. The present price of sulphate of potash in Cuba is $55 per ton which would give to the potash a value of $110 per ton; the 18,000 tons of potash contained in the molasses have then a value, at the current price of $1,980,000.

In addition to the potash, molasses contains a small but very appreciable quantity of nitrogen, which I will, in the absence of detailed analysis of Cuban molasses, take as being ·5 per cent.; then, there is contained in the molasses, 3,000 tons of nitrogen, having a market value of $1,200,000 when valued as commercial fertilizer.

In addition there is a small quantity of phosphoric acid in molasses, which will not be taken into account.

The following tabulated statement gives the gross value of the three principal products of the molasses output, based on a production of 2,500,000 tons of sugar:—

Alcohol, 40,000,000 gallons, worth 20c. a gallon	$8,000,000
Potash, 18,000 tons, worth $110 a ton	1,980,000
Nitrogen, 3,000 tons, worth $400 a ton	1,200,000
	$11,180,000

It is one thing to make a calculation showing the possible value of the products to be obtained from the molasses produced annually in Cuba, but before these can easily be realized, it is necessary to demonstrate the possibility of a market for them. I believe that a very extended use for the alcohol capable of being produced locally can be found within the limits of the sugar plantation in the following cases:—

(*a*) Alcohol-burning locomotives.

(*b*) Alcohol-burning tractors, to be used in propelling ploughs, cultivators, and other agricultural implements.

The 18,000 tons of potash contained in the molasses produced annually in Cuba, are several times more than is the quantity imported annually into Cuba for use as a fertilizer, which amounts at present to about 3,000 tons. I am informed that great difficulty would arise in the marketing of this product, since the world's supply of potash is controlled by a German syndicate prepared to crush any competition; this monopoly of potash is keenly resented in the United States, where any source of supply would be eagerly welcomed, and where we should have to look for a market.

I would, in addition, point out to you that the recovery of alcohol, potash and nitrogen from the molasses presents no technical difficulties, as many plants on the Continent of Europe already work up beet molasses; the process is simple, and the plant not expensive; I estimate that ten centralized distilleries, located at different points in Cuba, could be erected for a capital cost of, say, $1,800,000, and that these would be capable of treating the whole molasses output of Cuba.

This subject of molasses utilization has been written to death in the technical journals of the last few years, but I do not think any harm will be done if the possible magnitude of the industry is placed before you, even when unaccompanied by any definite statistics. The one outstanding trouble in Cuba is shortage of labour; the increase of the capacity of a limit of labour through the medium of mechanical appliances, will always be of great benefit to a community such as exists in Cuba; a cheap source of power at present almost wholly unutilized, is available; and I believe that it would be greatly to the advantage of Cuba

as a whole, if the Government did all in its power, by liberal egislation, to foster and develop a molasses alcohol industry.

WHITE SUGAR.

.... It may be of interest if I categorically state to you my position on the white sugar question :—

(a) Any well-equipped factories can at small extra expense produce directly from cane, a sugar of a quality perfectly fit for direct consumption.

(b) This sugar, though pleasing in appearance, will yet suffer when compared with a product that has been treated with bone-black.

(c) In the cane there exists certain colouring matters; some of these may be removed, but others continue throughout the process of sugar-making, although by suitable processes their intensity may be masked.

(d) The colour of raw sugar is not wholly due to the film of molasses which surrounds the crystal, but is also due to colouring matter which pervades the crystals, forming an integral part of it.

(e) As long as colouring matter remains in the juices no process will enable a really white sugar to be made.

(f) As far as we know at present, the use of bone-black or similar substance whereby the colouring matters are completely removed from the crystal. is the only means of obtaining a really colourless crystal.

(g) The United States of North America is, and will remain, our natural market; the inhabitants of these States have been educated to demand the very finest grade of sugar, and as long as our customers are willing to pay for appearance independent of actual sugar value, I do not think it would be advisable to put on the market, by a direct process, a nearly white sugar.

(h) I, however, believe that the production of a sugar, of say, 99·5 per cent. test, would be the most economic method to both initial producer and ultimate consumer.

Summarizing the above report, I would submit to you :—

(1) The comparatively backward state of agriculture in Cuba due chiefly to an economic reason, which is the combination of low selling price of the product, and high rate of labour. With this combination, agriculture is forced to adopt an extensive rather than an intensive policy.

(2) With the high rate of labour, every possible encouragement should be given to means whereby the efficiency of the unit of labour is increased.

(3) Such an increase in efficiency may be looked for in the adoption of power-operated agricultural implements.

(4) The fuel necessary to operate these implements may be obtained in the form of alcohol from the molasses at present produced in Cuba, from which an inadequate return is now obtained.

(5) A large number of Cuban factories sacrifice efficiency to capacity, and capital invested with a view to increase the efficiency of the factories, will be specially remunerative.

LAND SETTLEMENT SCHEME IN ST. LUCIA.

The Land Settlement Schemes in the West Indies have been reported upon from time to time, and general accounts of these have been published in previous numbers of the *West Indian Bulletin.*

In Volume XI, p. 194, an account was given of the working of the Land Settlement Scheme in St. Vincent, and more recently, further and additional information on the subject in reference to other Colonies has appeared in Volume XIV, No. 1, which contains papers on Land Settlement Schemes in Grenada and St. Vincent.

The St. Lucia Government has now embarked on a similar undertaking in that island, of which a general preliminary account is given herewith. This is reprinted from the Annual Report of the Agricultural Department of St. Lucia,1913-14.

ST. LUCIA.

REGULATIONS MADE BY THE GOVERNOR IN COUNCIL FOR THE SALE OF CERTAIN CROWN LANDS IN THE ISLAND OF SAINT LUCIA UNDER THE AUTHORITY OF THE CROWN LANDS ORDINANCE, 1878, AMENDMENT ORDINANCE, 1913.

[December 31, 1913.]

1. These Regulations shall apply to the Crown Lands known as Réunion, Valois and Le Riche, situate in the quarter of Choiseul in the Island of St. Lucia hereinafter called 'The land'.

2. The land shall be surveyed before any allotment of it is made, and the administration and disposal of such land and of all details connected therewith shall, subject to these regulations and to such orders as may be given by the Governor, be entrusted to an officer hereinafter styled the 'Land Officer'.

3. In making the survey the following Reserves shall be made :—

(1) All ponds and wells, the beds and banks of rivers and of any important stream or tributary, and a space of half a chain around the source and on either bank thereof;

(2) Swamps, exposed ridges, and such forest as may be deemed necessary for the purpose of Forest Conservation

(3) Such land as on recommendation of the Imperial Commissioner of Agriculture, the Governor in Council may approve as being necessary and desirable to be reserved for the uses of the Agricultural Department of the Colony;

(4) Such land as may be necessary for roads or paths to each allotment or group of allotments;

(5) Such land as may be requisite for villages;

(6) Any continuous tract of altogether precipitous or uncultivable land;

(7) Such land for any other public purposes as the Governor in Council may approve as necessary or desirable for the general good.

4. The remainder of the land shall be divided into allotments of not less than 2, and not more than 5 acres each, and no allotment shall exceed 5 acres except with the approval of the Governor in Council. In surveying the land for allotment, the Surveyor shall as far as possible include in one allotment any cultivation of an existing tenant on the land.

5. Each allotment shall be numbered and shall have its number clearly displayed on some part of it.

6. Every corner of each allotment shall be marked by iron pegs, and the general outline by dragon's blood or immortel plants, which plants shall be carefully tended by the allottee.

7. When the survey is complete the Land Officer shall proceed to value each allotment, and shall as soon as possible submit to the Governor a list of the allotments with the value of each. On approval of the valuations by the Governor in Council the value of each allotment shall be recorded in a Register to be kept as hereinafter provided.

8. The Land Officer shall then by notice in the *Gazette*, and by means of Posters, or in any other way he may deem desirable, invite applications in writing (which must be made on a printed form to be obtained from the Land Officer) for allotments, and on the expiration of thirty days from the date of the notice shall proceed, subject to the Governor's approval, to allot the same in accordance with the following regulations; Provided, however, that he shall not make an allotment of land to any person who is already an owner of land, without the sanction of the Governor. Every person to whom an allotment is made shall be given a conditional permit of occupation in the form annexed to these regulations.

9. In selecting applicants for allotments priority shall be given first to those who are prepared to pay down the whole value of the lots, and secondly to those who are prepared to pay not less than 20 per cent. of that value, taken in order of date of application: Provided, that an existing tenant shall have the first choice of purchasing the allotment within which his cultivation falls, unless the Governor, on the report of the Land Officer, shall decide that such tenant is otherwise ineligible.

10. The remainder of the purchase money of an allotment on which 20 per cent. or more has been paid shall be divided into eight equal parts, and the allottee shall on the expiration of the second year from the date on which his conditional permit of occupation (which will be the date of the first payment on account) was issued to him by the Land Officer, and thereafter on the same day in each year, for eight consecutive years, pay annually, as an instalment, one of those parts.

11. When all the applications from persons who are able to pay cash, or not less than 20 per cent. of the purchase money have been dealt with, the Governor may, in his discretion, allot

to the other applicants, according to the dates of their applications, the remaining lots of land, if such applicants be recommended by the Land Officer, and considered eligible by the Governor.

12. Such persons shall receive from the Land Officer a conditional permit of occupation of the allotment in respect of which they have been selected, on condition of paying for such allotment one-tenth part of the purchase money; and at the expiration of one year from the date of such permit and at the same date in each succeeding year, a further one-tenth part of the purchase money shall be payable.

13. The Land Officer shall keep a Register, in the form approved by the Governor, in which shall be recorded in parallel columns—

(*a*) the number, area, and value of each allotment,

(*b*) the name of the allottee,

(*c*) the date of the allotment,

(*d*) the amount paid previous to the allotment,

(*e*) the sums paid on account of instalments and the dates of such payments,

(*f*) any other information which the Governor may prescribe.

14. An allottee may at any time pay off any instalment outstanding. An allottee may at any time pay on account of any instalment any sum not less than four shillings.

15. The conditions of tenure of allotments shall be as follows :—

(*a*) Every purchaser shall for a period of ten years reckoning from the date of allotment, reside ordinarily in the island of St. Lucia, commencing to do so within not more than three months after obtaining a conditional permit under these regulations, unless the Land Officer, with the approval of the Governor, shall otherwise permit.

(*b*) No land may be alienated, let, or incumbered, for a period of ten years from the date of allotment, without the consent of the Governor. The word 'alienated' does not refer to or include an involuntary alienation as in the case of descent or bankruptcy; nor an alienation partly involuntary as in the case of a devise by will.

(*c*) No exclusive right shall vest in any person to any spring, stream, pond, well, or other natural source of water situate in or flowing through any land.

(*d*) The Governor may at any time resume possession of any part or parts of an allotment not exceeding one-tenth of the said allotment, for roads, on paying therefor at the same rate per acre as that at which the allotment was originally sold, and also for the value of such crops as may be on such selected line of road.

16. On failure by an allottee of an allotment to comply with any of the conditions of tenure hereinbefore detailed, the Land

Officer shall immediately report all the facts of the case to the Governor, who shall enquire as fully as possible into all the circumstances of the default, whereupon the Governor in Council may order that the right to such allotment and all crops and all instalments paid, and all other rights of the allottee, shall be forfeited, without any appeal to any Court, or may make such other order as the circumstances of the case may require.

17. Notice of an order so made shall be served upon the allottee or left at his last known place of abode, and no act of re-entry shall be necessary, and such allotment or house spot shall be at the disposal of the Governor, either to re-sell then, or at any future time.

18. On payment in full by an allottee of the purchase money of an allotment, he shall be entitled to a grant of the same Every grant of land shall be deemed to be subject to an exemption from sale of, and a reservation to the Crown of the ownership of, and the right to search for and get, all petroleum which may be found on or under such land. Grants shall be recorded in the Registry of Deeds Office free of all cost to the allottee, except stamp duty, if any.

Made by the Governor in Council this 31st day of December, 1913.

SAMUEL OKELL,
Clerk of Councils.

REPORT ON THE WORKING OF REUNION ESTATE FOR THE YEAR ENDING MARCH 31, 1914.

Réunion estate,
Choiseul, Saint Lucia,
March 31, 1914.

Sir,

I have the honour to submit, in quadruplicate, a report on the working of Réunion estate for the year ending March 31, 1914.

PURCHASE.

2. This property was purchased by the Government at public auction for a total sum of £1,713 on February 22, 1913, and I assumed the duties of Officer-in-Charge, in conjunction with the duties of my substantive office, on March 3.

BUILDINGS.

3. Upon careful inspection of the sugar works it was found that fairly extensive repairs would have to be carried out to enable the cane grown by the Metayers to be handled in accordance with the terms of purchase.

4. The mill and water wheel by Fletcher & Co., London, is one of the largest and best of its kind in the island, and is in excellent working condition.

5. The battery, consisting of three large copper and two small iron tayches, had to be entirely dismantled and rebuilt. The

copper tayches having been burnt in a few places were patched before being re-erected.

6. The whole of the plant has now been put into thorough repair, and should not need any serious expenditure for many years to come.

7. The buildings, however, require careful attention to bring them into good condition. To undertake the whole of this work at one time would entail a somewhat heavy expenditure, which the present sugar crop does not justify. I therefore recommend that this work be done gradually, until these buildings are in good condition.

8. In making the above recommendation I am looking more to the future than the present. Choiseul and the surrounding districts are in every way as suitable for the cultivation of limes as many of the lime districts in the neighbouring island of Dominica, *provided that the same care and attention be given to the question of wind-belts as is done in the latter island.* In this connexion I should like to mention that the rainfall in these districts is quite sufficient for the successful cultivation of this crop; and to correct the erroneous impression which exists locally on this point, I would add that some of the largest and most prosperous lime estates in Dominica receive only an average annual rainfall of between 60 to 70 inches.

9. Our policy, therefore, in connexion with the repairs to these buildings should be guided by the above knowledge, so that in the event of the lime industry extending in this quarter, the Government would have in readiness a large factory capable of meeting the demands of small growers along the Leeward coast, who are at present debarred from the advantages offered by the factory in Castries owing to difficulties of transport.

10. The dwelling house was found to be in an unsafe condition and a large portion of it beyond repair. It was therefore decided to take it down, and to erect quarters for the Junior Instructor and Field Overseer from the sound material.

11. Accommodation for the Officer-in-Charge, who is also Assistant Agricultural Superintendent, was provided by the removal of his former quarters from Union.

12. The whole of the work in connexion with the Officers' Quarters was carried out by the Public Works Department.

INTRODUCTION OF NEW CANE VARIETIES.

13. Attention has been given to the introduction of new cane varieties for the purpose of ascertaining the varieties best suited to this district, and with the object of rendering the present cultivation more profitable.

14. Seven $\frac{1}{4}$-acre plots were laid out, and planted up with the following: D. 109, D. 625, D. 116, B. 147, B. 376, B. 208, and the local White Transparent. Plant canes of the first six varieties were obtained through the Agricultural Superintendent at St. Kitts.

15. Records will be carefully kept as to the suitability of these varieties for local conditions, and, later on, cuttings will be distributed to Land Settlement Holders.

TENANTS.

16. Seeing that many months would have to elapse before the necessary legal arrangements could be made for the disposal of the land under a Land Settlement Scheme, arrangements were made to rent out for one year as much of the land as possible to peasants, for the cultivation of ground provisions, at a rental of 18s. per acre.

17. Other land near the Choiseul River and village boundary, being unsuitable for general cultivation, has been reserved for house sites, at a monthly rental of one shilling. Twelve sites have already been taken up, and others are likely to follow.

18. A sum of £23 15s. *6d.* has been received from these tenants during the year.

AGRICULTURAL DEPARTMENT.

19. About 60 acres of land near the south-eastern boundary of the village has been reserved for the use of the Agricultural Department, to make possible the removal of the Experiment Station and plant nurseries from Union, where the frequency of flooding has proved such a handicap to the general work of the Department. This transfer has left the spacious buildings at Union—which were no longer required for the use of this Department after the closing of the school there—free for other public purposes.

20. The details in connexion with this transfer and the laying out of the new Station at Reunion are dealt with at length in the Annual Report of the Agricultural Department for the year 1913-14.

VILLAGE EXTENSION

21. Choiseul is the most densely populated village in St. Lucia, and until the purchase of the Réunion estate by the Government no relief from this congestion was possible, owing to the high price asked by the owners for the land adjoining the village.

22. To improve this condition, a block of 6 acres of land belonging to the Réunion estate and adjacent to the north western boundary of the village has been surveyed, and will shortly be available for village purposes.

GOVERNMENT RESERVE.

23. A narrow strip of land comprising about 3 acres, running along the eastern boundary of the village, and separating the latter from the new Experiment station, has been reserved for the present, as it was deemed unwise to dispose of the land immediately adjoining the village until its requirements were more fully known. In the meantime this land is being worked by metayers.

LAND SALES

24. A piece of land comprising 15 acres, adjoining the Trou Babet River and bounding with the new village extension was sold to the Rev. Father Roger for £120, this land being desired for Parish purposes only, such as the building of new schools, which at present are situated in an unsuitable locality.

25. The section of land known as 'Cleonne' was upon survey found to contain only 29 acres as against the 'forty-one' more or less as advertised in the sale notice. Owing to this section being so far from the remainder of the estate—some 2 miles along the road to Soufrière—it was decided to dispose of it in small areas to the adjacent peasant proprietors. For this purpose it was divided into three lots and sold for a total sum of £145, thus a little more than covering its original cost and subsequent expenses incurred in connexion with the survey.

PUBLIC ROAD DIVERSIONS.

26. The danger which existed to travellers between the villages of Choiseul and Soufrière created by a precipitous chasm encroaching upon the northern side of the main driving road near the former village has been removed by diverting the road through the lands of Réunion estate. This improvement was only made possible by purchase of this property, the price formerly asked for the necessary piece of land to carry out this work being prohibitive.

27. Land necessary for the northern approach to the Choiseul bridge now being erected has also been procured without having to meet legal claims of compensation to private owners

LAND SETTLEMENT.

28. Land settlement schemes have been established in Grenada and St. Vincent during the last few years, and it was decided to give a similar scheme a trial in St Lucia. With this object in view 165 acres of the Réunion, Valois and Le Riche land was surveyed and divided into forty-seven lots ranging from 2 to 5 acres each. Roads are being laid out throughout this area to give each allottee a right of way.

29. Regulations for the sale of these lots were made by the Governor in Council and published in the *Official Gazette* of December 31, 1913. The administration and disposal of these lots is entrusted to the 'Land Officer' subject to such orders as may be given by the Governor. The duties of this officer have been undertaken by the writer.

30. Upon the valuation of these lots being approved by the Governor in Council, the Land Officer will invite applications for them and proceed to allot the same in accordance with the Regulations.

31. The close proximity of the new Agricultural Experiment Station and Plant Nurseries where all kinds of cultivation and agricultural operations are in daily progress should be of practical assistance to the land settlement holders, and the Land Officer

who resides on the estate is available and willing at all times to render any assistance that lies in his power. It is sincerely hoped that this scheme will meet the co-operation of the peasants and enable them to work their holdings on more lucrative lines, and be the means of checking—even in a small measure—the daily emigration from the island.

RECEIPTS.

A total sum of £260 17*s.* 6*d.* has been received from the following sources during the financial year ending March 31, 1914 :—

	£	s.	d.
Sale of land	165	14	3
Rents	23	15	4
Crop account	71	1	3
Miscellaneous		6	8
	£260	17	6

VALUATION OF LAND SETTLEMENT LOTS AT 'REUNION', 'LE RICHE', AND 'VALOIS' CHOISEUL.

Lot.	Area. A.	R.	P.	Apprized value. £	s.	d.
1	3	0	34	22	15	0
2	4	1	21	29	15	0
3	3	2	03	24	10	0
4	2	3	16	11	0	0
5	3	1	20	22	15	0
6	3	1	36	17	10	0
7	3	1	28	24	10	0
8	4	3	12	33	5	0
9	2	3	04	19	5	0
10	3	2	36	27	12	6
11	3	0	20	23	8	6
12	3	0	18	18	15	0
13, 14	6	0	26	45	18	6
15	3	1	11	22	15	0
16	2	2	14	18	15	0
17	4	3	14	35	12	6
18	4	3	14	35	12	6
19	4	2	05	33	15	0
20	3	0	00	22	10	0
21	3	3	37	30	0	0
22	4	3	11	33	5	0
23	2	1	19	13	10	0
24	2	0	16	14	17	6
25	4	3	37	31	10	0
26	5	0	04	35	0	0
27	4	3	01	33	5	0
28	4	1	32	31	10	0

VALUATION OF LAND SETTLEMENT LOTS AT 'REUNION' 'LE RICHE', AND 'VALOIS' CHOISEUL.—(*Concluded.*)

Lot.	Area. A.	R.	P.	Apprized value. £	s.	d.
29	2	1	17	15	15	0
30	4	3	01	33	5	0
31	6	2	34	47	5	0
32	2	0	29	15	18	6
33	2	1	14	16	17	6
34	2	0	05	15	0	0
35	4	1	10	31	17	6
36	4	0	35	21	5	0
37	3	1	11	16	5	0
38	2	1	11	11	5	0
39	2	2	17	15	0	0
40	3	3	14	22	10	0
41	3	2	12	21	0	0
42	2	3	15	16	10	0
43	2	2	36	16	10	0
44	2	1	15	13	10	0
45	3	1	13	19	10	0
46	4	0	01	20	0	0
47	3	3	31	20	0	0
Total	167	1	13	1,112	0	6

(Sgd.) ARCHIBALD J. BROOKS,

4.4.'14. Land Officer.

Valuations approved by the Governor in Council, under the Regulations dated December 31. 1913. this 8th day of May 1914.

(Sgd.) SAMUEL OKELL.
Clerk of Executive Council.

MEMORANDUM ON THE GEOLOGY OF THE GROUND WATERS OF THE ISLAND OF ANTIGUA, B.W.I.

BY T. WAYLAND VAUGHAN,

Geologist in Charge of Coastal Plain Investigations,
U.S. Geological Survey.

THE PROBABILITY OF OBTAINING A SUPPLY OF ARTESIAN WATER.

An Artesian well, according to the usage of both most European and most American geologists, is a well in which the water is under hydrostatic pressure, and will therefore rise higher than the level of the water-bearing stratum, where it is penetrated, although the water may not rise so high as the surface of the ground at the mouth of the well. Some of the more important factors determining the presence of artesian reservoirs, in so far as they apply to Antigua, will be stated, as follows:—

2. The accumulation of ground water under pressure requires the presence of a pervious bed into which the water may percolate, and which must be both overlain and underlain by an impervious bed which will prevent the water from escaping. Besides the upper and lower confining beds, the *water-bearing stratum must also be closed along its sides so that lateral diffusion of water may be prevented.* In order that the charge of water which is usually received directly from meteoric sources may percolate downward to lower beds through the water-bearing bed, this bed with its confining strata, must have an appreciable inclination which is technically designated, dip.

3. The three well-known physiographic districts recognizable in Antigua are as follows: (1) South-west Volcanic district, (2) Central Plain, (3) North-east Limestone district. The characteristic features of these districts are ascribable to differences in rock composition, and to geological structure. The Central Plain is underlain by more easily eroded rocks than is either of the areas of higher land bordering it.

4. Geologically the island is composed of three principal kinds of rock, and a subordinate fourth kind, which are as follows:—

(i) Older volcanic rocks, pebbles of which are found in the base of the Oligocene marls at Willoughby Bay and at other localities, and a series of stratified volcanic tuffs, sandstones, and clays, interbedded with which are fresh-water cherts. This series of rocks underlies the surface of the Central Plain and dips under the Oligocene marls and limestones along a north-west south-east line.

(ii) A thick deposit of Oligocene marls and limestones (the Antigua formation and Hodges Hill sandstone of J. W. Spencer),

which constitutes the country rock of the North-east Limestone district. It also outcrops in the Central Plain and at Seaforth, Yorks, Willocks, Falmouth Harbour, and Indian Creek in the South-west Volcanic district. Dr. Tempany has submitted to me a specimen of orbitoidol limestone from Indian Creek, and at Falmouth I collected in limestone abundant specimens of a species of Orbitoides, which was also found at Willoughby Bay, Wetherill Mill, Wetherill Point, Mayers Village, and many other localities in the Limestone district. The limestone in the Volcanic district shows clear evidence of metamorphism by heat.

(iii) Igneous rocks, including those of the Volcanic district, which owes its physiographic aspect to their presence. Dr. Tempany, I believe, is correct in his opinion that at least most of the rocks of the Volcanic district belong to the newest of the important geologic formations of the island, for it is clear that volcanic rocks have largely been intruded into, or extruded over, Oligocene marls and limestones, and are therefore geologically younger than the latter. However, it should be recognized that there may be in this district igneous rocks of different ages because the existence of igneous rocks older than the marls and limestone is proven by the pebbles found in the basal part of the exposure at Willoughby Bay. The discrimination of the different kinds of igneous rocks, deciphering their respective ages and mapping them, will require protracted, detailed investigation.

(iv) The 'Horizontal marls' of Purves are land debris washed from the hill-sides near the seashore in the Limestone district and accumulated at lower levels.

5. The important rocks of Antigua, considered from the standpoints of the probability of obtaining an artesian water supply, therefore comprise a series of compact, stratified, volcanic tuffs, sandstones and clays, and fresh-water cherts, overlain by calcareous marls and limestone, and the igneous rocks, especially of the South-west Volcanic district. Neither the tuffs, sandstone, clays, and cherts, nor the igneous rocks are efficient water carriers, as they possess too compact a texture. Besides being deficient in this requisite quality, the former set of rocks contains saliniferous beds, which render much of the water derived from them unfit for use. The limestone is a water carrier, and, as the copies of analysis supplied by Dr. Tempany show, contains water of good quality, except that, as is characteristic of all limestone water, it is hard.

6. The geologic structure of Antigua in its broad features is simple, but its detailed is complicated. The rocks of the central plain usually dip north-eastward at angles ranging from 10° to 20°, while those of the Limestone district dip in the same direction at angles ranging from 10° or less to 12°. The structure is approximately monoclinal as regards dip, but many faults break the continuity of the rocks; Purves noted several, but there are many more. Many of them nearly parallel the strike of the formations and cause the reappearance of the same bed along the line of direction of the dip. The peculiar elongate hills, with a steep south-west or west and a gentle north-east or east slope, so frequent in the Limestone district, probably owe their origin to faulting. The kind of faulting prevalent in

Antigua is caused by compressing forces. One additional feature of the limestone needs to be mentioned. The strike of this formation, the only water carrier of importance in the island, is form north-west to south-east, and at each end of its outcrop there are greatly developed sea cliffs as at Wetherill Point, and along the east side of Willoughby Bay. The strata are so arranged and so exposed as to give the optimum condition for access of sea-water to beds lying below sea-level. Furthermore there is no confining impervious bed overlying the limestone.

7. Having presented the foregoing outline of the geology of Antigua in its bearing on the probability of the occurrence of artesian water on the island, the geologic data may be compared with the statement of conditions essential for the occurrence of such water.

(i) The only water-bearing formation of importance is the limestone of the Limestone district.

(ii) There is an impervious stratum below this formation, but there is no overlying confining bed.

(iii) The exposure of the formation along the sea at both its north-west and south-east ends offers favourable opportunities for its impregnation with sea-water at depths below sea-level.

(iv) The geologic conditions of Antigua do not satisfy the requisites for procuring a water-supply from *artesian* sources.

WATER-SUPPLY FROM OTHER THAN ARTESIAN SOURCES.

8. This subject has been so admirably treated by Dr. Tempany in his article on The Water-supply of Antigua that I can add little or nothing to what he has said.

As bearing on the source of the salt in the beds underlying the Central plain, I wish to present information obtained during my recent expedition, and inferences based on that information. That the last important change of the sea-level with reference to the land was by submergence of the land is attested by the indented shore line, indicating submerged valleys, the absence of terrace benches, and the presence of a peat bed 4 feet thick, composed of terrestrial plants, submerged to a depth of about 20 feet in St. John Harbour. It is important to note that the 'Horizontal marls' contain the remains of no indigenous marine organisms. Previous to this submergence there was a period of emergence, evidently sufficient to join Antigua and Barbuda into one land area. The last change of sea-level, subsequent to the important submergence mentioned, was a minor recession of the sea, producing an emergence of a few feet, perhaps between 3 feet and 6 feet. The geologic evidence as I interpret it, is distinctly contradictory to the hypothesis that the waters of the Central Plain are salt because that district has lately been submerged, and that there has not been sufficient time since then for the salt accumulated during that submergence to be washed out. The hypothesis advanced by Dr. Tempany appears to me to be the correct one, viz., there are saliniferous beds interbedded in the deposits underlying the Central Plain, and these beds render the water salt.

9. The copies of the analyses, and the map with the position of the wells plotted on it, which have been submitted to me, show that good shallow well water may be obtained in the Limestone district back from the seashore, provided that the wells be not too deep. Waldron's wells, Numbers 23 and 24, bear on the importance of not sinking the wells to too great a depth. The former well is about 40 feet, and has a Chlorine content of 288 parts per 100,000, too high for use; while the latter well, which is shallower, has 41·6 parts of Chlorine to 100,000, and although salt may be detected by taste, there is not enough to render it non-potable (the total solids, however, are high). The experience with the tube well at Fitches Creek illustrates the importance of not penetrating the beds underlying the limestone. By using care not to have the bottom of the wells appreciably below sea-level, and by keeping the bottoms of the wells above the geologic formation underlying the limestone, an abundant water-supply should be obtainable from shallow wells in the Limestone district. A word of caution should be offered regarding such wells. As limestones are frequently traversed by underground solution channels, wells sunk in such rock are liable to pollution. They should be subject to careful inspection, and should be guarded against possible sources of contamination.

10. The wells in the Central Plain near its north-east boundary appear uniformly to be bad, but some wells further west are passable. As an indigenous water-supply from wells in this area is uncertain, it is evident that provisions for supplying it from outside sources are desirable, unless water is locally impounded or collected in cisterns.

11. The wells in the South-west Volcanic district, except those very near the sea, are satisfactory, and show the possibility of developing considerable quantities of water in the alluvial fillings along stream-ways, and at the foot of the talus slopes of hills. The impounding of additional water in a manner similar to that already done at Wallings Reservoir is worthy of consideration.

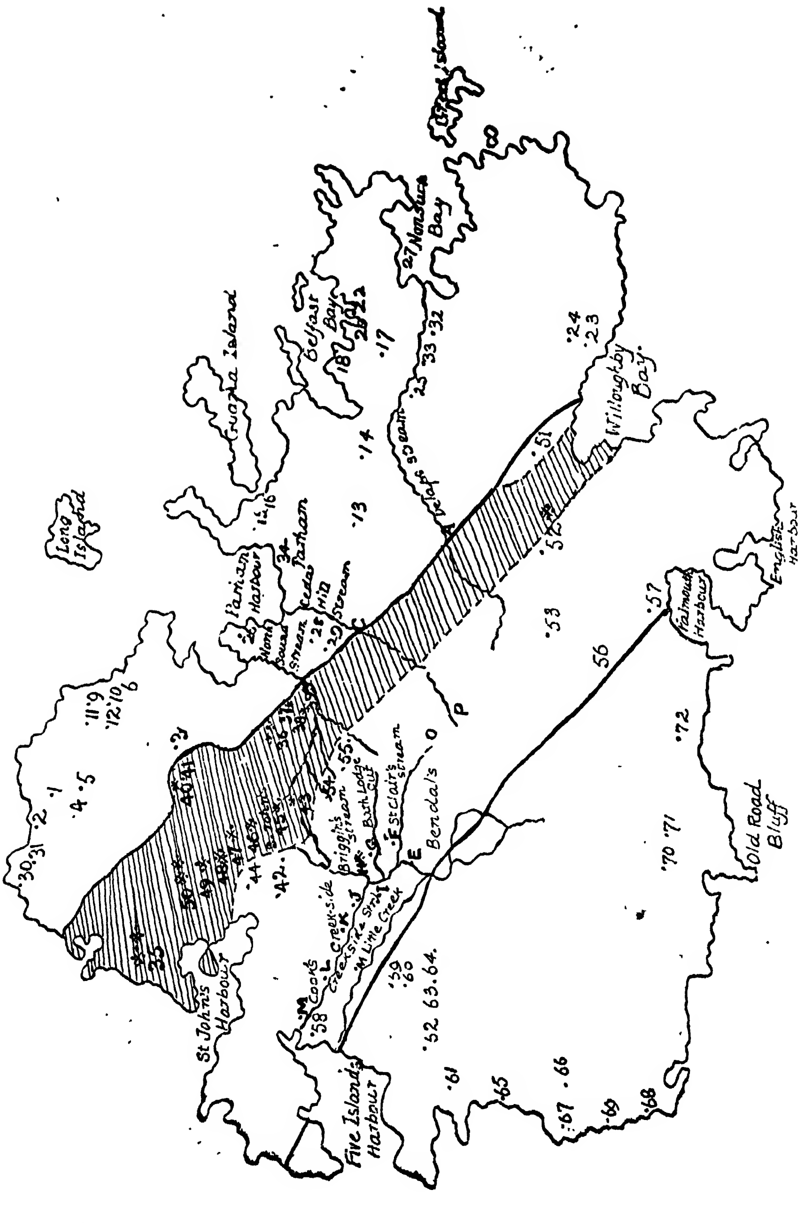
12. In conclusion, it may be said, although no supply of artesian water may be expected in Antigua, the development of an adequate supply may be expected from three sources, viz:—

(1) Shallow wells in the Limestone district.

(2) Shallow wells in the alluvial fillings along stream-ways, and at the foot of talus slopes in the South-west Volcanic district.

(3) Impounding water, especially in the Volcanic district, where it appears there are valleys adapted for damming.

13. As the sinking of wells and the damming of valleys, the accumulation of water in reservoirs, and its distribution to consumers, come within the province of the engineer, it would be impertinent for me to make suggestions on these subjects.



MAP OF ANTIGUA SHOWING MAIN GEOLOGICAL DIVISIONS AND COURSES OF PRINCIPAL STREAMS.

THE GROUND WATERS OF ANTIGUA.

BY H. A. TEMPANY, D.Sc. (LOND.), F.I.C.

Government Chemist and Superintendent of Agriculture for the Leeward Islands.

In a paper published in the *West Indian Bulletin* (Vol. XII, p. 530), a general survey of the chemical characteristics of the various sources of supply of water in the island of Antigua was brought forward by the author.

Since the publication of the account in question, a good deal of detailed consideration has been given to the subject with a view to augmenting the existing sources of supply. As a result, considerable additions have been made to existing information relating to the question, and at the present time it may be claimed that markedly extended knowledge of the subject has been accumulated. It is with a view to summarizing this, and at the same time presenting a concise account of the main features, that this paper has been prepared.

In relation to the general conditions influencing the existence of the subsoil water-supply, on which the successful sinking of wells and the occurrence of springs of fresh-water depend the following condensed summary is reproduced from an article by the writer, which appeared in the *Agricultural News*, Vol. XII, p. 155.

'Each island in the West Indies constitutes an entirely separate and distinct subsoil water system in which the reserve of contained moisture is continuously finding its way to the sea. The majority of the islands are wholly or partially volcanic in origin, and in those of smaller size, at any rate, the conditions most usually met with consist of a central peak or mountain range rising to a height of from 2,000 to 4,000 feet above sea-level, and possessing numerous minor lateral spurs and escarpments, sloping down more or less evenly to sea-level at the coast. The central portions of these mountain ranges are usually composed of impervious volcanic rock, whilst the mountain slopes and valley bottoms are generally covered to a considerable depth with volcanic detritus, and alluvium, of a character more or less permeable.

'Under conditions such as these, the rainfall is naturally greatest in the more mountainous central region, and diminishes as the coast is approached. The cultivated lands, on the other hand, are in most cases confined to the comparatively level tracts of the coastal region, the mountainous centre being left largely in a state of nature.

'In the case of certain islands, notably Trinidad, Barbados, Antigua, Barbuda, and St. Croix, a somewhat different state is presented, volcanic formations being there replaced, wholly or in part, by more or less permeable sedimentary strata, the well-marked central mountainous region giving place, to a considerable extent, to undulating ranges of hills of lower elevation.

'In all cases, however, each island constitutes a system in which subsoil water continually drifts down to the sea from the central region, the general character and rate of the flow being governed by local physical conditions in each case, but being naturally least during dry periods.'

It is important that these general principles should find acceptance, as they may serve to clear away a certain amount of misconception as to the possibility of obtaining supplies of artesian water by boring to deep levels. In this connexion, the memorandum by Dr. Vaughan, on the Geology of the Ground Waters of Antigua, which accompanies this paper, is worthy of attention.

For the purpose of extending the water-supply in Antigua, two alternative methods of procedure are available. The first of these consists in the sinking of wells at appropriate spots, and the pumping of the water derived from them to the points to which it is required to distribute the supply. The second comprises the erection of dams in suitable localities, for the purpose of impounding a certain amount of the flood water which at present runs to waste, and is lost during periods of heavy rains.

In the paper previously referred to, it was pointed out that, for purposes of classification, the underground waters of Antigua may be divided into three groups, viz: (a) those derived from limestone rocks underlying the northern and eastern portion of the island; (b) those derived from the older sedimentary rocks of the central plain; (c) those derived from the low-lying lands of the volcanic area in the southern district of the island.

It was further shown, by means of collected series of analyses, that the underground waters contained in districts (a) and (c) were in the majority of cases of satisfactory quality for domestic and industrial consumption, but those included under the head (b) were frequently so heavily charged with saline constituents as to render them unusable.

That this is the case, is to be attributed to the fact that in the central plain, the surface strata are in many places heavily charged with salt, which serves to contaminate shallow wells, and at the same time also renders saline to a greater or less extent, all surface waters that are impounded within the salt-bearing region.

The existence of these salt-bearing beds must therefore be regarded as a very important limiting factor in relation to any scheme for the improvement of the island water-supply, more especially as from its physical configuration, and the close-textured and retentive character of the beds of which it is composed, the central plain naturally constitutes the most suitable district for impounding surplus run off water for consumption.

In order to permit of the distribution and character of the underground water of the island being readily compared, the annexed summarized statement showing the principal analytical characteristics of over seventy shallow wells and springs in all parts of Antigua has been prepared, the results being given in grains per gallon. Appended to this is a statement showing

the depth and character of the yield from each well, while accompanying it is a sketch map of the island, on which the location of each well is indicated by means of a number corresponding to those given in the analytical summary.

On the map are also shown the approximate boundaries of the three main geological divisions of the island, together with the courses of some of the principal streams which drain the area of the central plain.

Those wells, which possess a high saline content, are indicated on the map by means of asterisks: when the saline content of waters exceeds 100 grains of salt to the gallon, a single asterisk is placed against them; when it exceeds 300 grains of salt to the gallon, they are indicated by a double asterisk. A survey of the results will show that, in the Limestone and Volcanic area, excessive salinity of the well waters is to be explained, for the most part, by close proximity to the sea, combined in some cases with a limited collecting area, whereby sea-water has seeped in and rendered the wells salt.

In relation to the central plain, it is however seen that the salinity of well water is not evenly distributed throughout the area in question

Examination of the map will show that the most saline samples occur in the region around Gunthorpes in the centre of the island, and extend in a belt about $\frac{3}{4}$-mile broad through Gambles to the sea north of St. John's.

Description of Location of Wells and Springs.

1. Royals Well. Depth to bottom of well 41 feet. Depth of water 3 feet 6 inches.
2. Cedar Grove Spring. Close to the sea. Depth of well to surface of water about 25 feet. Supply of water good.
3. Thibous Well. Near Thibous works. Depth of well 36 feet. Yield said to be good.
5. Gravenors Well. Depth to water level 16 feet. Yield good.
6. Winthorpes Well. Depth to water level about 20 feet. Yield good.
7. Fitches Creek Well. About 50 yards from the sea and on low-lying land. Depth not very great. Yield good.
8. Millars Well. Situation similar to No. 7, but further north. Yield good.

9 & 10. High Point Wells, No. 1 & No. 1. Very close to the sea. Both about 15 feet deep. Yield of water good.

11 & 12. High Point Wells, No. 3. Same locality as Nos. 9 and 10, but about $\frac{1}{3}$-mile inland. Depth of both wells considerable, probably between 30 and 40 feet. Yield of both good.

13. Parham New Work. Depth of 20 feet. Yield said to be good, but fallen off in very dry weather.
14. Gilberts. Depth about 15 feet to water surface. Yield good.

15. Parham Lodge. On low-lying land about 300 yards from salt marsh. Depth to water surface not very great. Yield good.
16. Crabbs. On low-lying land. Depth small. Yield good. Close to the sea.
17. Zion Hill. On low-lying land some little distance from the sea. Depth 16 feet. Yield abundant.
18 & 19. Seatons Well. On low-lying land, close to the sea. Yield good.
20 & 21. Mayers Well. On seashore at Spencers Bay. Yield good.
22. Comfort Hall Well. On seashore at Spencers Bay. Yield good.
23. Waldrons I. Not very far from the sea. Depth about 40 feet.
24. Waldrons II. A short distance south of east of Waldrons I. Exact depth not known, but shallower than Waldrons I.
25. Elliotts Spring. About 1 mile from the sea. Very shallow, situated practically in the stream bed. Yield very good.
26. Blackmans Spring. Not far from the sea. Exact depth unknown.
27. Grays Well. On the seashore.
28. Cedar Hill Well. On low-lying land about, $\frac{1}{3}$-mile from the sea. Depth of water surface about 16 feet.
29. North Sound Well. About $\frac{3}{4}$-mile from the sea, on very low-lying land, a short distance inside the limestone outcrop. Depth to water surface about 7 feet. Yield good.
30. Crosbies Well No. 1. Close to the sea.
31. Crosbies Well No. 2. Close to the sea.
32. Gaynors Bristols Spring. Near stream bed. About $\frac{1}{2}$-mile from the sea.
33. Gaynors Hole. A short distance from, and similarly situated to, No. 32.
34. Parham Rectory. On low-lying land close to the sea in Parham. Shallow. Yield good.
35. Gambles Spring. Shallow well on low-lying land. Exact depth not known.
36. Gunthorpes. Shallow well on low-lying land in the Factory yard. Depth about 7 or 8 feet.
37. Gunthorpes Factory Bore Hole No. 1. Depth 40 feet.
38. Gunthorpes Factory Bore Hole No. 2. Depth about 40 feet.
39. Grove. Shallow well on low-lying ground. Exact depth not known.
40. Cassada Garden. Shallow well on low-lying ground near the border of the limestone area.
41. Osbornes Spring. Shallow well about 14 feet deep. Yield good.

42. Ottos. A shallow surface spring near the foot of Ottos hill. Yield abundant.

43. Belmont. Shallow well about 14 feet deep, not far from Belmont works, on low-lying ground.

44 to 50. All of these are shallow surface wells varying in depth; as one approaches to the sea, then the level of the water approaches nearer to the surface.

51. Blakes. Shallow well on low ground. Exact depth not known.

52. Morris Loobys. " " " " "

53. Bodkins. " " " " "

54. Herberts. On low-lying ground. Depth about 6 feet. Yield said to be good.

55. Ferris Farm. On low-lying ground. Depth 21 feet. Yield good.

56. Liberta Old Well. On moderately low ground. Depth between 30 and 40 feet. Yield good.

57. Falmouth Spring. Shallow spring about 7 feet deep. Not far from the sea at Pattersons.

58. Seaforths. Shallow well, exact depth not known. Yield good.

59. Jennings. About 14 feet deep, about 1 mile from the sea. Yield good.

60. Jennings. Shallow well, exact depth unknown; about 300 yards from 59. Has since fallen in, not having been cared.

61. Bolans. Shallow well sunk in the stream bed, about 1 mile south of 60. Has since fallen in.

62. Blubber Valley Spring. 63 and 64 represent the same well at different seasons.

63 & 64. Blubber Valley Well. Both springs are shallow and lie midway between 60 and 61. Yield abundant.

65. Tottenham Park. About ¼-mile south-west of 61, and about the same distance from the sea.

66. Orange Valley. About 1 mile south-east of 65, and about ¾-mile from the sea. Yield moderate.

67. Fry's Well. About ½-mile west of 66, and about ¼-mile from the sea. Yield good.

68. Johnson's Point. About 1 mile south of 67, close to the sea.

69. Crabb Hill. About ½-mile south of 67, close to the sea.

70. Claremont. About 3 miles south of 68, and about ½-mile from the sea. Yield good.

71. Claremont. Similar to 70.

72. Doigs. Shallow spring about 2½ miles south of 71, and about ¾-mile from the sea. Yield good.

	Royals Well. No. 1.	Public Spring Cedar Grove, No. 2.	Piggots Spring, No. 3.	Thibous Well, No. 4.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids . ..	57 4	102 2	56·0	98 7
Temporary hardness .	29 1	35 7	17 2	36 8
Chlorine	5·5	26 4	14·7	24·5
Equivalent as sodium chloride	9·0	43·5	22 8	40 4

	Gravenors Well, No 5.	Winthorpes Well, No. 6.	Fitches Creek Well, No. 7.	Millars Well. No. 8.
	Grains per gallon.	Grains per gallon.	Grains per gallon	Grains per gallon.
Total solids	104·3	88·2	117·8	128·1
Temporary hardness	39·2	87·2	31·4	33·0
Chlorine	18·2	13·9	44·1	54 0
Equivalent as sodium chloride	30·0	23·0	72·7	88·9

	High Point Well, No 9	High Point Well, No. 10.	High Point Well, No. 11.	High Point Well, No. 12.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon
Total solids	536·2	625·8	114·1	84·[illegible]
Temporary hardness ...	28·9	88·9	23·5	30·[illegible]
Chlorine	270·2	377·8	20·6	9·[illegible]
Equivalent as sodium chloride	445·8	523·7	35·0	16·[illegible]

	Parham New Work. No. 13.	Gilberts, No. 14.	Parham Lodge, No. 15.	Crabbs, No. 16.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	77·0	91·0	142·1	134·4
Temporary hardness ..	39·7	36.7	25·2	39·2
Chlorine	6·2	16·4	61·6	63·0
Equivalent as sodium chloride ..	10·3	27·0	101·4	103·6

	Sion Hill Well. No. 17.	Seatons Well. No. 18.	Seatons Well, No. 19.	Mayers Well, No. 20.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	57·4	193·2	360 5	483·0
Temporary hardness ...	26·4	36·7	14·0	44 4
Chlorine	9·1	72·8	163·1	215·3
Equivalent as sodium chloride ...	15·0	120·4	260·1	354·4

	Mayers Well. No. 21	Comfort Hall Well, No. 22.	Waldrons I. No. 23.	Waldrons II. No. 24.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	343·7	483·0	452 2	125·9
Temporary hardness...	53·2	45·2	21 7	42·0
Chlorine	170·0	237 0	201·6	29·1
Equivalent as sodium chloride	280·2	390·5	332·2	48 0

	Elliotts Spring. No. 25.	Blackmans Well, No. 26.	Grays Well. No. 27.	Cedar Hill Well, No. 28.	North Sound No. 29
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids ...	126·1	111·5	256·2	85.3	99·3
Temporary hardness	39 6	34·0	35·0	42·0	20·3
Chlorine	16·8	174·9	99·3	12·6	34·1
Equivalent as sodium chloride	27·7	288 2	163·5	20·9	56·2

	Crosbies Well, No. 1, No. 30.	Crosbies Well, No. 2, No. 31.	Gaynors Bristols Spring, No. 32.	Gaynors Hole, No. 33.
	Grains per gallon.	Grains per gal'on.	Grains per gallon.	Grains per gallon.
Total solids	445·7	196·6	105·0	82·6
Temporary hardness	21·8	20·8	35.7	18.1
Chlorine	250·9	94.5	31·9	11·0
Equivalent as sodium chloride	413·5	155·6	52·6	42·0

	Parham Rectory, No. 34.	Gambles Spring I, No. 35.	Gunthorpes Shallow Well, No. 36.	Gunthorpes Factory Bore Hole, 40 feet deep, No. 1. No. 37.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	314·3	964·6	1,323·0	460·1
Temporary hardness	40·5	28·0	196 0	9·9
Chlorine	114·4	483·0	618·8	178·6
Equivalent as sodium chloride ...	188·6	795·8	1,020·0	294·3

	Gunthorpes Factory Bore Hole, No. II. No. 38.	Well at Grove, No. 39.	Well at Cassada Garden. No. 40.	Spring at Osbornes, No. 41.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	404·5	...	378·9	268.8
Temporary hardness	16·8	...	...	18·2
Chlorine	173·7	516·7	165·9	128·8
Equivalent as sodium chloride	285·7	883·0	273·4	212·0

	Ottos, No. 42.	Belmont, No. 43.	Well at Cross Street & Nevis Street, No. 44.	Well at Nevis Street & Temple Street, No. 45.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Totals solids	211·4	379·4	...	...
Temporary hardness	14·4	37·8	...	...
Chlorine	47·2	146·4	40·5	101·3
Equivalent as sodium chloride	77·8	211·1	76 7	167 0

	Redcliffe Street and Corn Alley. No. 46.	Long Street and Thames Street, No. 47.	Corn Alley and Newgate Street. No. 48.
	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	...	..	...
Temporary hardness	...	...	...
Chlorine	155·4	81·9	109·2
Equivalent as sodium chloride	256·0	135·0	180·0

		North Street and Wilkinson Street, No. 49.	St. George's Street, No. 50.	Blakes, No. 51.
		Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids			..	142·1
Temporary hardness ...	.		...	61 6
Chlorine		157·2	315·0	35·7
Equivalent as sodium chloride	13 9	28·3	37·5	33·6

	Morris Lubys. No. 52.	Bodkins. No. 53.	Herberts. No. 54.	Well at Ferris Farm. No. 55.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	209·3	87·5	86·8	79·1
Temporary hardness	11·3	39·2	26·6	37·4
Chlorine	84·3	17·2	18·5	20·3
Equivalent as sodium chloride	138·9	28·3	37·5	33·0

	Liberta Old Well, No. 56.	Falmouth Spring, No. 57.	Seaforths, No. 58.	Jennings Well, No. 59.	Jennings, No. 60.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	91·0	63·3	88·3	106·4	156·8
Temporary hardness ...	23·2	18·9	32·5	44·1	56·9
Chlorine	28·8	14·7	4·9	19·9	19·3
Equivalent as sodium chloride ...	47·5	24·2	8·1	32·8	81·2

	Bolans. No. 61.	Blubber Valley Spring, No. 62.	Blubber Valley Well, No. 63.	Blubber Valley, No. 64.	Tottenham Park, No. 65.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	213·6	62·7	53·2	72·8	142·1
Temporary hardness ...	75·1	32·4	31·8	32·5	61·6
Chlorine	58·2	10·8	9·5	16·8	35·7
Equivalent as sodium chloride ...	95·9	17·8	15·7	27·6	72·2

	Orange Valley. No. 66.	Frys Well. No. 67.	Johnson's Point, No. 68.
	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	79·1	126·0	516·5
Temporary hardness	11·6	28·0	30·7
Chlorine	19·6	26·6	221·5
Equivalent as sodium chloride	32·3	43·8	365·0

	Crabb Hill Well. No. 69.	Claremont Spring. No. 70.	Claremont Joe Merry Spring. No. 71.	Doigs, No. 72.
	Grains per gallon.	Grains per gallon	Grains per gallon.	Grains per gallon.
Total solids	238·0	61·6	65·8	72·9
Temporary hardness ...	29·3	38·2	11·6	39·2
Chlorine	107·6	10·5	24·1	17·2
Equivalent as sodium chloride	247·3	17·3	33·9	28·3

In the opposite direction the line of salinity extends to the shores of Willoughby Bay, but as far as the data available allow of an opinion being expressed, the salinity appears to decrease in intensity as one approaches the north-eastern side.

Of peculiar interest also are examples No. 45 and 40, which though situated within comparatively short distance of the most highly saline portion of the region in question, nevertheless yield waters of quite low saline content.

A comparison of the data in respect of the line of wells running across St. John's also yields interesting information, and indicates that salinity increases directly in a line running from Ottos to Gambles, in a direction south-east to north-west.

In a region such as the central plain of Antigua, of which the physical configuration is low-lying and level, while the rainfall is comparatively small, one finds, as is to be expected, that certain well-marked stream beds exist, which serve to carry off flood water during periods of heavy rains, at which time they often function as streams of some size, while during dry weather, on the other hand, the flow becomes extremely sluggish or ceases altogether, a series of separate pools being formed at favourable points.

In such circumstances, when the strata which they traverse are impregnated by salt, these waters will tend to become charged with saline matter, the salt content being lowest during wet weather, and tending to increase greatly during drought. Consequently the character of such stream waters during dry periods serves to indicate the relative salinity of the strata which they traverse.

This is well shown by the following series of analyses of the waters of Delaps, North Sound, and Cedar Hill streams, taken at points where they traverse the saline beds of the central plain.

As during the course of this paper it will become necessary to refer frequently to such surface drainage waters, the points at which samples of this type have been taken are indicated on the map by letters, to distinguish them from the wells which, as stated, are shown by numbers :—

	Delaps Stream,	
	A. 1. Taken after moderate rains.	A. 2. Taken after 2½ months' dry weather.
	Grains per gallon.	Grains per gallon.
Total solids	244·0	340·9
Chlorine	96·9	148·6
Sodium chloride	159·3	244·9
Temporary hardness	34·2	30·1

	North Sound Stream, B.	Cedar Hill Stream, C.
	Grains per gallon.	Grains per gallon.
Total solids	...	125·2
Chlorine	94·9	51·1
Sodium chloride	156·1	8·48
Temporary hardness	...	11·2
Sodium carbonate	...	11·9

Hitherto it has been customary to explain the occurrence of these salt-bearing strata on the assumption that in recent geological time, the island was submerged beneath the sea to a depth of 50 feet or so below its present level; under these conditions, the lower-lying regions would have become covered with sea-water. When subsequent slow re-elevation took place, it was presupposed that, on emergence, the low-lying lands, for long periods, existed in the form of mangrove swamps and salt ponds, while the final drying up of them left the surface layers impregnated with salt.

Such a supposition would offer a satisfactory explanation of the observed facts, provided that all lands of level configuration possessing a heavy and retentive soil and subsoil, and situated at an elevation not more than 30 or 40 feet above sea-level, showed these characteristic saline deposits. It is beyond conception that, at so late a geological period as the theory in question postulates, one portion of the island should have been more elevated than another adjoining portion, and yet show no geological evidence of very recent folding and contortion.

In the face of this, the existence of moderately fresh springs and wells in the area in question, together with the marked variation in the saline contents of wells situated in the saline region, causes the hypothesis to be open to suspicion. The suspicion is strengthened when the character of the surface waters of the Bendal's and Creekside area are examined.

For convenience of reference, the physical configuration of the Central Plain area may be briefly described at this point. In general it comprises a broad tract of low-lying level land, which does not rise to a height of much more than 50 or 60 feet above sea-level. Running through the centre of this area is a line of low hills, which attains at its highest point to perhaps 200 feet above sea-level, and corresponds with the outcrop of a series of flinty beds intercalated with the strata of this region. This ridge pursues a line diagonally across the island from St. John's to Willoughby Bay, the line being, however, broken at various points by a series of faults.

There is further a line of low hills running north and south from Scots Hill to Drews Hill a short distance east and south-

east from St. John's; these latter elevations are the result of volcanic intrusions, which have caused the strata to be uplifted and altered at these points.

The Bendal's valley itself constitutes the south and south-easterly portion of the Central Plain district; it is typically an extremely level tract of land of considerable extent, possessing an elevation generally of not more than 30 or 40 feet above sea-level; the soils and subsoils of this region are of a particularly heavy and retentive character; the district is separated from the salt-bearing Gambles-Gunthorpes region by the low ridge previously referred to, and by the Scotts Hill and Drews Hill range.

It will therefore be seen that, in any general subsidence of the level of the island such as has been postulated to account for the existence of the saline deposits at Gunthorpes and elsewhere, this district must have shared in the inundation which took place, while the natural conditions would be decidedly favourable to the formation of surface saline deposits in the manner indicated.

No analyses of springs or wells from this locality are available to help to elucidate this point; but, on the other hand, a considerable amount of information has been accumulated in respect of the surface waters.

The Bendals valley constitutes the largest single drainage area of the island; the line of drainage is known as the Bendals-Creekside stream, which is a water course of some size receiving several tributaries in its course; the situation of the stream is indicated on the map. Its head-waters are derived from the mountainous district south of Bendals Factory. After bifurcating and rejoining again, the stream finally divides and finds its way to the sea by means of two roughly parallel channels. Of these, the more southerly is known as Little Creek, while the more northerly and larger branch constitutes the Bendals-Creekside stream proper.

As the result of the severe and prolonged drought experienced during 1912, attention was directed to this stream as a possible additional source of water-supply. It had for long been known that the lower reaches were decidedly salt, but it was supposed that owing to the very low-lying character of the country in this region, the salinity was due to tidal flow inwards of sea-water.

Consequently, on the initiative of His Excellency Sir Hesketh Bell, K.C.M.G., Governor of the Colony, a dam was erected during 1913, on the lower reaches of the stream about 5 feet above their former level, with the object of preventing the intrusion of sea-water.

As a result, a very large volume of water was impounded, and it was found that after a comparatively short interval of time, the saline content of the water became markedly reduced; the reduction of the salinity experienced, however, was found not to be sufficient, after a considerable interval, to permit of the water being used for human consumption, except in cases of emergency, or for irrigation. It was therefore concluded that the stream was probably being contaminated at some point of its course by saline deposits.

With a view to localising this contamination, and ascertaining whether it was distributed throughout the drainage area in question, or confined to one particular point, a detailed examination of the course of the stream was made during the early part of the year 1914, samples of the water being drawn at intervals along its course, while the main tributaries and branches were also sampled. The survey in question extended between the point at Cooks, at which the dam already referred to had been erected, and Bendals Factory where the two branches bifurcate ; partial analyses of each sample were carried out in the Government Laboratory for the Leeward Islands.

The head-waters of the stream are locally known as Body Ponds, and form the source from which the public water-supply of the town of St. John's is derived. The water is pumped from that point to the Greyshill reservoir near the town for distribution. The composition of this source of supply, and the manner in which it varies with the season, have already been recorded in the paper on the Water-supply of Antigua already referred to. The following data give an approximation for the composition of it under average circumstances :—

		Grains per gallon.
Total solids	...	32·8
Chlorine ...	...	8·0
Equivalent sodium chloride	...	13·0
Temporary hardness		15·0

From the foregoing it will be observed that the head-waters of the stream contain relatively small amounts of dissolved saline material.

The analytical data for the various samples taken during the course of the survey are summarized in tabular form below. As is the case with the other results for surface and stream waters, the samples are identified by means of letters, and the locations from which they have been derived are indicated on the map, in each case. It should be added that the samples were taken during dry weather, so that the results are not liable to be obscured owing to excessive dilution resulting from flood-water.

	E. Grains per gallon.	F. Grains per gallon.	G. Grains per gallon.	H. Grains per gallon.	I Grains per gallon.
Total solids	57·1	15·9	53·8	451·9	65·3
Chlorine	12·3	3·3	19 1	174·0	23·7
Equivalent sodium chloride	20·3	5·5	32·1	286·3	39·0
Temporary hardness ...	10·9	2·0	10·0	27·9	13·5
Sodium carbonate ...	11·3	4·8	6·1	2·9	8·2

	J. Grains per gallon.	K. Grains per gallon.	L. Grains per gallon.	M. Grains per gallon.	N. Grains per gallon.
Total solids ...	98·0	129·6	113·1	356·4	50·3
Chlorine	36·4	54·0	51·2	162·0	13·4
Equivalent sodium chloride ...	60·0	89·0	84·4	267·0	22·0
Temporary hardness	12·8	19·7	18·1	16·7	10·1
Sodium corbonate	2·2	2·2	2·6	1·8	9·5

It will be observed that, as it is to be expected, the content of dissolved salts tends to increase somewhat as one proceeds along the stream bed ; thus the total solid content of the sample E taken from Bendals stream at the railway Bridge, which though not high, is greater than that of the head-waters.

Of the tributaries, that known as St. Clairs stream, sample F, shows only 15·9 grains per gallon of total solids ; this stream is of comparatively small importance however, and drains only a small area.

KEY.

E. Bendals Stream, by railway bridge.
F. St. Clairs Stream.
G. Bath Lodge Gut.
H. Briggins Stream.
I. Creekside Stream below junction of Bendals Stream and Bath Lodge Gut.
J. Creekside Stream, by fan mill above Creekside bridge.
K. Creekside Stream by Creekside bridge.
L. Cooks Dam overflow.
M. Cooks Dam, below dam.
N. Little Creek.

Bath Lodge stream, sample G, shows a total solid content of 58·8 grains per gallon, and 32·1 grains per gallon of sodium chloride ; the salt content is slightly higher than that shown by sample E, but at the same time cannot be regarded as in any degree excessive.

The sample taken from Briggins stream, H, is of considerable interest, and appears to afford a partial key to the situation observed ; the total solid and the sodium chloride contents are both very high, amounting to 451·9 and 286·3 grains per gallon, respectively.

Sample I is taken from the main body of the stream, below the junction of Bath Lodge gut and Bendals stream. It shows a total solid content of 65·3 grains per gallon, and a sodium chloride content of 39·0 grains per gallon, slightly higher than either of the two former examples. The point at which the sample was taken is situated a short distance above the junction of Briggins

stream with the main body of water, and the slightly higher value shown by this sample as compared with the two parent streams is probably accounted for by backflow from the Briggins tributary.

The next sample, J, was taken about 100 yards below the junction of Briggins stream. It shows a total solid content of 98 grains per gallon, and a sodium chloride content of 60 grains per gallon. The effect of the influx of the Briggins tributary is seen in a marked inrcease in the salinity of water. The increase noted would correspond to the following volumes of the different contributing bodies of water, namely, Bendals stream, six volumes; Bath Lodge gut, three volumes: and Briggins one and a half volumes, which corresponds to rough eye estimates of their relative size.

The next sample, K, was taken from Creekside stream at Creekside Bridge, about ¼-mile below sample J; here a further increase in the saline content of the main body of water is seen, the values rising to 129·6 grains per gallon of total solids, and 89·0 grains per gallon of sodium chloride. The further rise is probably to be accounted for by the fact that some little distance above the point at which the sample was taken, a small dam has been erected, which precludes the intrusion of sea-water beyond that point. Between this and Cooks dam a very large reservoir has been constituted, and from it the residues of sea-water are being slowly washed out, a process which may be expected to take place gradually after the first big dilution following the erection of Cooks dam.

Sample L represents the water taken from immediately above Cooks dam; here a total solid content of 113·1 grains per gallon is shown, while that of sodium chloride amounts to 84·4 grains per gallon; the slight fall in the saline contents from the value found at Creekside Bridge is probably due to drainage of surface water from the large area of level land on both sides of the stream; no tributary joins the stream between Creekside Bridge and Cooks. Sample M is drawn from the stream below Cooks dam; it will be seen that it contains 356·4 grains per gallon of total solids, and 267·0 grains per gallon of sodium chloride; the direct effect of the dam in keeping back sea-water is shown by a lowering of the sodium chloride content, amounting to 182·6 grains per gallon. In this connexion it is of interest to record the analysis of the water from the stream at Creekside Bridge under normal conditions before the dam was erected. It is as follows:—

	Grains per gallon.
Totals solids ...	413·7
Chlorine	188·0
Equivalent sodium chloride...	311·2
Temporary hardness	17·7

The similarity of the composition of this sample with that of sample M from below the dam at Cooks is very striking, and

shows conclusively that the influence of the influx of sea-water was felt as far as Creekside Bridge.

We thus see that the original salinity of the water at Creekside Bridge was due to two causes ; the first of these, namely the influx of sea-water, has been removed by the erection of the dam ; the second, namely, the effect of a salt laden tributary, remains.

Sample N is also of interest ; it represents the water of Little Creek, the branch of the stream which breaks off at Bendals and finds its way to to the sea by an independent channel roughly parallel to the larger stream. The water from this stream is of quite good quality, and is uncontaminated with salt, as the result of the course which it follows.

In face of the evidence presented in the foregoing pages, we are forced to conclude that saliniferous deposits of the character encountered on the Gambles-Gunthorpes line do not occur in the Bendals valley, taken as a whole, and on this account the theory of recent submergence, as an explanation of the occurrence of these deposits, does not hold good.

Of the various bodies of water contributing to the Bendals valley drainage system, only one, namely Briggins stream, sample H, shows a very high saline content. The course of this stream is shown on the map ; it will be seen that it takes its rise on the slopes of Scotts Hill and Drews Hill, in which locality, the evidence supplied in relation to surface wells and springs, indicates the existence of salt–bearing beds.

As an alternative hypothesis to that previously held, it may be suggested that the saline deposits under consideration are interbedded with the rocks of the central plain, which outcrop along the line where the salt beds occur.

Further evidence in support of this view is afforded by means of data secured in relation to two series of borings conducted recently at Gunthorpes in the Central plain and Fitches Creek in the Limestone district.

At Gunthorpes two bore holes were sunk to a depth of about 40 feet in the yard of the Central Sugar Factory. Analytical data in respect of the water from these two bore holes are given in the summarized table of analyses, Nos. 37 and 38. Reference to this will show that the samples in question possessed contents of sodium chloride amounting to 294·4 and 285·7 grains per gallon, respectively, the result demonstrating that, so far from being surface deposits a few feet only in thickness, to a depth of 40 feet below the surface, the strata are impregnated with salt. It is however significant, that the water from the lower levels possesses a decidedly lower salinity than that derived from the upper few feet. This is probably to be accounted for by the fact that at this point there has been an accumulation of salt at the surface owing to its having been continuously brought up from lower levels by capillarity.

The boring trials at Fitches Creek further confirm the view that the saline beds are interstratified with the rocks of the geological series. The point at which these trials were carried

out, lies about 700 yards within the limestone outcrop, and about 400 yards from the sea; the spot is indicated on the map. The ground level at this point was found to be approximately 10 feet above sea-level.

The boring lay through soft marls and calcareous clays; water was first encountered at a depth of 35 feet, and drilling was continued to a depth of 59 feet in all. At a depth of 52 feet the boring passed through a bed of hard compact rock, and entered non-calcareous strata, at which point the water suddenly altered its character and became markedly saline. Previously it had been moderately fresh.

The analytical characters of the water are exhibited in the following data:—

	I. Before penetrating non-calcareous strata.	II. After penetrating non-calcareous strata.
	Grains per gallon.	Grains per gallon.
Total solids	107·1	...
Chlorine	25·6	153·0
Equivalent as sodium chloride ...	42·1	252·0
Temporary hardness ...	13·3	31·2

It may be added that waters derived from the lower levels showed evidences of having been under pressure, and forced considerable amounts of solid matter up the casing tube of the bore hole.

The similarity in analytical composition shown by sample (b) to those derived from the bore holes at Gunthorpes, is sufficiently striking to warrant the conclusion that they both are drawn from the same underground source.

The evidence therefore affords sufficient grounds for believing that the saline beds in question are interstratified with the rocks of the central plain, and underlie the limestone formation.

Their outcrop in general appears to follow a line about ¾-mile broad from St. John's to Willoughby Bay, and occurs to the north east of the flinty beds referred to previously.

As stated, the region is much intersected by faults and has been penetrated by volcanic intrusions at certain points. As the result of this the outcrop of the salt deposits has apparently become displaced to some extent at certain points, and the effect is probably indicated in the occurrence of moderately fresh springs contiguous to the salt-bearing area as seen in Nos. 54 and 55.

The approximate location of the saline deposits is indicated on the map by means of shading, the shaded area representing the locality in which they occur.

It does not appear that these salt deposits exist at any point in a pure state, but rather that the stratified beds are highly impregnated with salt along the line of their occurrence. Evidence in favour of this view is given by an examination of the strata as they outcrop at Scotts Hill; at this point the rock is characteristically a compacted siliceous sandstone of very fine texture, which has been altered to some extent by contact metamorphosis. Interbedded with this compact material are thin layers of a much more friable rock of a dark brown colour; the sodium chloride content of this interbedded rock was determined on samples in the Laboratory, and found to amount to as much as 2·18 per cent. of its total weight. As the rock in question occurs at a height of about 130 feet above sea-level, the result affords further conclusive evidence in favour of the theory concerning the nature of these deposits that has already been outlined.

Some information as to the character of the deposits in question can be deduced from analyses of the mineral salt contents of the waters of this region. Such a series of analyses has been performed on samples taken from the following points: (a) from a well situated under a house close to the Government Laboratory in the north-west portion of St. John's; (b) from Gunthorpes Factory, the sample being taken from a shallow well sunk in the Factory yard; and (c) from Cedar Hill stream.

In each case the results are expressed as a percentage of the total solid content, and in each instance the total solid content of the water in grains per gallon is given:—

	(a) St. John's.	(b) Gunthorpes.	(c) Cedar Hill.
	Grains per gallon.	Grains per gallon.	Grains per gallon.
Chlorine	35·6	54·2	41·1
Carbonate	12·8	0·5	10·6
Sulphate	10·2	9·9	4·6
Calcium	4·2	4·3	2·1
Magnesium	2·9	4·1	0·9
Sodium	26·1	...	31·2
Potassium	0·7	...	1·2
	92·5		91·7
Undetermined ...	7·5		5·3
Contains sodium carbonate	8·1	nil	9·7
Total solids	214·5	1,695·0	125·1

A point in relation to these samples is that (a) and (c) show appreciable amounts of sodium carbonate, but that this constituent is absent in the in case of (b). In general, the occurrence of greater or less quantities of sodium carbonate frequently forrows a feature of the shallow ground waters of Antigua.

In the collected series of analyses, the sodium carbonate together with the alkaline earth are returned under the head of Temporary Hardness, but the following additional data, however, further illustrate the manner in which sodium carbonate may occur :—

	I. Spring at Gaynors.	II. Spring at Blubber Valley.	III. Ottos Spring.	IV. Jennings.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	93·1	62·7	176·4	156·8
Sodium carbonate	14·8	17·4	13·2	11·2

	V. Bolans.	VI. Body Ponds.	VII. Bath Gut Lodge.	VIII. Little Creek.
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Total solids	213·6	35·6	65·3	50·3
Sodium carbonate	65·9	7·6	8·2	9·5

In this connexion it is interesting to refer to a paper by Dr. J. C. Thresh, on the alkaline waters of the London basin, which appeared in the *Chemical World*, Vol. I, p. 393, and Vol. II. p. 32. in which it was shown that this constituent was likely to arise when waters containing appreciable amounts of sodium chloride, and also charged with calcium carbonate percolated through sandy strata, interaction taking place under these conditions between the two constituents in question. and resulting in the formation of sodium carbonate The absence of this constituent, and the very small amount of calcium carbonate found in the

Gunthorpes sample, would appear to demonstrate that sodium carbonate does not form a normal constituent of saline deposit, but has been formed subsequently as the result of chemical reaction on the lines indicated.

In concluding this discussion of the character of these saline deposits, a word may be said as to the possible effect exerted by them in the limestone district. As has been shown, they directly underlie the limestone formation, and are apparently separated from it at most points by an impervious substratum. If at any point this substratum should become broken, it seems reasonable to suppose that salt from these deposits will tend to be brought by capillarity to the surface of the ground, and it is further reasonable to expect that under these conditions, considerable reaction would take place between the calcium carbonate and the limestone, and the dissolved salts. It is characteristic of the lands of the northern and eastern portion of the limestone district that they show localised small patches on which sugar-cane refuses to grow in a satisfactory fashion, the canes presenting a characteristically etiolated appearance. These patches are locally known as 'gall patches', and have formed the subject of much speculation as to their origin, in the past. It is tentatively suggested that in reality these patches may represent points at which the soluble salts from the underlying strata have penetrated to the surface in the manner described. It is hoped, by means of further investigation, denfiitely to decide this point at a future date.

With regard to the subsoil waters of the southern districts of the island, it has already been pointed out that in general they are satisfactory in quality, but certain points in this connexion require that attention should be directed to them.

It may be remarked that the line of demarcation between the volcanic beds of the southern district and the deposits of the Central plain is largely hypothetical, the effect observed being one of increasingly intense volcanic intrusion as one proceeds in a south-westerly direction. As the result of the action of these intrusions on the overlying rock, there is evidence to show, that at some points in the southern district, localised saline deposits have become formed. In this connexion, the results of analyses in relation to the subsoil and surface waters in the Blubber Valley area may be quoted. The locality in question constitutes the first of the typical regions encountered in the south-west district of the island, and comprises a level plain filled with alluvium to a considerable depth, and surrounded on three sides by steep hills. Examination of the subsoil waters of this district shows that, in the region near to the flanking hills, the saline contents are liable to be somewhat high, but that in the Central plain they sink to small proportions. This is illustrated by reference to Nos. 54 to 64 in the table of analyses. Nos. 59, 60, and 61 are from wells sunk near the foot of the flanking hills on either side; while Nos. 62, 63 and 64 are from wells sunk in the central portion of the area in question. It will be seen that the former show a much higher saline content than the latter.

The explanation would appear to be as indicated above, that in the region of the hills, contact metamorphosis has in some unexplained way led to the formation of local saline deposits and

consequent pollution of the ground waters; in the central area the effect in question is absent, and the water is in consequence, of satisfactory quality.

The practical inference is that in selecting sites for wells in southern district, too close proximity to the surrounding hills should be avoided.

The practical outcome of the observations contained in this paper may be summarized as follows: —

In the limestone district there are good prospects of obtaining supplies of underground water at suitable points. The localities at which wells are sunk should be selected with due regard to the following points: (*a*) that they should be situated at not too great a height above sea-level so as to avoid having to penetrate unnecessary thickness of rock; (*b*) they should be situated a sufficient distance within the limestone outcrop to ensure that, at the point selected, the rocks to be penetrated are of adequate thickness, and afford a large enough gathering ground; (*c*) they should be situated at a sufficient distance from the sea to obviate the risk of the supply being contaminated by percolation of sea-water. In addition care must be exercised in conducting boring operations to avoid passing through the limestone strata, and penetrating the underlying rocks which contain the saliniferous deposits.

In the southern district of the island, there is good prospect of obtaining moderate supplies of water from wells sunk in the alluvial fillings of the valley bottoms, but in choosing sites for such wells, it is advisable to avoid approaching too near to the bases of the surrounding hills.

In the Central plain it is inadvisable to look for a supply of water either by wells, or by means of dams erected for the purpose of impounding surface flood water in the region covered by the saline deposits. To the south of this region, however, there appear to be prospects of obtaining satisfactory supplies of water by the sinking of wells, or preferably by the erection of dams. The characters of the waters that may be impounded in this latter district have already been exemplified in the series of analyses from Bendals Creekside stream; they are further shown in the following analyses of other streams in this locality:—

	O. Renfrews Stream. Grains per gallon.	P. All Saints Stream. Grains per gallon.
Total solids	31·4	50·1
Chlorine	0·9	9·8
Sodium chloride ..	1·47	17·2
Temporary hardness	0·3	0·1
Sodium carbonate ...	1·1	2·9

The locality in question offers special advantages for the erection of dams, inasmuch as the close-textured character of the soil and subsoil renders it difficult for water to penetrate through it. On this account, reservoirs constructed by erecting dams at suitable points in this locality will not be subject to loss of water by seepage, and in consequence, the necessity for puddling the interior with clay in order to ensure its holding water will be removed.

TWO PHYSIOLOGICAL AFFECTIONS OF SEA ISLAND COTTON IN THE WEST INDIES.

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In July 1914, that is to say, in the early part of the cotton-growing season, the attention of the Imperial Commissioner of Agriculture was drawn to the appearance in St. Kitts and Nevis, in what seemed to be threatening proportions, of certain malformed types of cotton plants. The writer was sent to investigate the outbreaks, arrived on July 19, and spent some three weeks in the two islands. The following observations were made, and the greater part of the accompanying information was collected, during that period. A brief account of the affections has already been published (Nowell 1914).

Two forms of abnormal growth were met with, which in their typical manifestations are quite distinct in appearance, and in some of their characters are directly opposite to each other. It will be convenient to describe them separately, leaving the consideration of their possible relationship to a later stage of the discussion They will be distinguished by the names 'loggerhead', and 'curly-leaf', respectively. The former is a vernacular name used in St. Kitts, the latter a descriptive term.

It should be understood at the outset that either form of abnormality may supervene after the plant has made considerable growth, in fact, the usual method of occurrence of the curly-leaf affection is in that way: and either may be thrown off, and normal growth resumed. The loggerhead affection in particular may appear in plants at any stage in which active growth is taking place, including very early stages. This is illustrated in the first plate, which shows two young plants of the same age from the same field; the one on the left began normally and then became affected, the other was affected early and then grew out normally.

DESCRIPTION OF CURLY-LEAF.

The general character of the curly-leaf affection is shown in the second plate. It is most noticeable on the upper part of the main shoot, but occurs also on the laterals. The internodes of stems and branches, and often the leaf-stalks grow out to be very long and lanky. The reproductive branches commonly have only two or three nodes, which makes the number of possible flowers small. The leaves from their earliest appearance are strongly crimped all round their margins; they are thin in substance, and pale green, tending more or less to yellow, in colour. In some cases there is a diffusion of still paler colour bordering the larger veins. In what seemed to be the more extreme cases examined, numerous small irregular holes with

LOGGER-HEAD COTTON.
YOUNG PLANTS.

a torn appearance occurred in the body of the leaf. and on its edges.

The effect of the onset of this condition on bearing is profound. There is a strong tendency for the flower buds to dry up, turn black, and drop at a very early stage in their development; very many are lost when the bracteoles are but 2 or 3 millimetres across, others at various later stages. Some plants are rendered completely barren even of flowers in this way. Of the flower buds which do succeed in developing, many fail to open; the outside of the petals becomes slightly discoloured pink and takes on a characteristic, rather woolly appearance. and as the corolla becomes mature, the margins of the overlapping petals towards the tip of the bud seem to lose their consistency and cling together, so preventing expansion. Complete withering of the petals follows. Flowers examined in the first visible stages of the process have been found to have the anthers already brown and withered. The effect is possibly produced from the first by gradual wilting of the petals from the margin inwards, or it may be that they lack from the first the consistency necessary for the expansion of the corolla. The condition was not further investigated.

In the fields where I examined the curly-leaf malady, the onset of the affection was too recent for observations on the amount, if any, of the production of bolls on the affected parts of the plants. All experience has shown that the yield from fields in which the condition is prevalent is very small.

Description of Loggerhead.

The most striking feature of the loggerhead form of growth is the shortening. to a greater or lesser degree. of the internodes of both stems and branches A plant which is affected at an early stage of growth assumes the form of a low dense bush, with the primary leaves, and the shortened reproductive branches with their leaves and flowers, all crowded together on the shortened vegetative axes. If the plant becomes affected only after normal growth has been made, then the tops of the main stem and of the vegetative laterals show similar close bunchy masses. The flowering laterals have numerous internodes, so that large numbers of flower buds are produced.

In respect of these features it will be seen that the loggerhead form is the exact opposite of the curly-leaf form, the contrast arising from the partial suppression of the internodes in the one case, and their elongation in the other.

The leaves of the loggerhead form are very distinctive. They are normal in thickness; the general colour is a dark green. usually distinctly darker than that of the leaves of normal plants; there is no tendency to the crimping at the edges which is the most conspicuous feature of the other form, but the leaf substance may be puckered along the main veins owing to their insufficient elongation; the secondary veins, instead of diverging at the usual wide angle may be tied at a narrow angle to the primary veins for some distance, apparently from the failure of the intervening ground tissue to expand. Such undeveloped spots

are almost transparent and of a light yellow colour. In many cases there is not this interference with the form of the leaf, but in all cases there is a definite mottled effect produced by the presence of lighter green or yellowish areas. This mottling is quite distinctive, and were it not that the term has already been used for another affection of cotton, loggerhead might well be known, in conformity with the very similar diseases of other plants, as mosaic disease. In all typical cases the mottling is quite different in appearance from the diffused yellowish discoloration along the course of the veins which has been already described as occurring in some cases of curly-leaf. A few examples have been noticed however, where in plants of the loggerhead form the light areas have followed the course of the veins. In such cases the yellow colour has usually been more definite than in the curly-leaf examples, but occasionally the approach is very close. This was seen in plants in which the suppression of the internodes was hardly noticeable.

As in the case of curly-leaf, large numbers of flower buds turn black and drop in their earliest stages. This symptom cannot however be regarded as a special character of these affections, since the same thing has been observed on cotton plants of normal form elsewhere when exposed to unfavourable conditions. It may be regarded as a method by which the cotton plant adjusts its production to external conditions, and as the earliest manifestation of the well-known habit of shedding.

The abnormal condition of the flowers described in connexion with curly-leaf also occurs in plants of the loggerhead form.

Observed Distribution.

As seen in St. Kitts and Nevis in 1914, curly-leaf was somewhat less erratic in its occurrence than the loggerhead affection. When present at all, it usually occurred pretty generally, through a field, though sometimes it was scattered. It was often very common in a field without the loggerhead form appearing at all, but cases were observed where it was mixed up with that, and with normal plants.

The most striking exhibition of loggerhead was seen in a field of full-grown plants on an estate situated on the eastern side of St. Kitts. A large proportion of the plants showed evidence of having been affected from a fairly early stage, though not very severely; that is to say, the plants, though bunchy, had made a fair amount of growth. Well developed flower buds were present in profusion, but few of them seemed able to open properly, and such bolls as were present were young. I was informed that according to previous experience, practically none of these would persist. The affected plants were not distributed in distinguishable patches, but had quite normal plants scattered indiscriminately among them. There was no sign of curly-leaf.

Another case of the fairly general appearance of loggerhead was reported as having occurred in the north of St. Kitts, but most of the plants had been pulled up when I visited the place. Those which remained were recovering, i.e., the newest growth was normal.

More commonly, the occurrence of loggerhead plants was distinctly sporadic; sometimes a very small number, even down to a single example, occurred in a large field, and over large areas of cotton, differing little in age or geographical position, they were quite absent.

ABSENCE OF PARASITIC ORGANISMS.

A most careful examination had previously been made of specimens forwarded for the purpose, without detecting the presence of any animal or vegetable parasite which could be regarded as responsible for either affection. Search in the field, and examination of recently collected specimens had the same result. There was no sign of fungus or bacterial attack, and such insects and mites as were found were equally common on healthy plants. The method of occurrence does not suggest the action of a parasite. Appearances indicate that the affections must be classed with physiological diseases and, by analogy, with the group which are regarded as being associated with enzyme disturbances.

CONDITIONS OF OCCURRENCE.

It is definitely the opinion of local observers that the appearance of curly-leaf is connected with dull rainy weather, and it is especially liable to occur in shaded and sheltered situations. Longfield Smith, whose observations in St. Croix are given below, finds in that island that the outermost rows of affected fields commonly remain normal.

Where the soil is sufficiently deep and permeable to prevent water-logging, as is eminently the case in St. Kitts, the effect of the conditions just described is to induce rapid and continuous growth. W. L. Balls (1912) has shown how very powerful is the inhibiting effect of direct sunshine on the growth of the cotton plant, and this is greatly increased by exposure. The upsetting, during very rapid growth, of the balance of the internal chemical processes is regarded as the cause of similar diseases of other plants.

There seems to be no doubt that normal growth is always resumed when dry sunny weather supervenes.

The evidence as to the conditions producing the loggerhead malady is more conflicting. Reference may again be made in this regard to the two plants found near each other in the same field, one of which was just recovering from, and the other just developing, the affection. Similarly, in the Experiment Station at Nevis, plants in one plot were recovering at the same time that plants in a plot separated only by a road were growing worse. Frequent examples were observed of two plants, one perfectly healthy and the other badly deformed, growing in close contact, with the bases of their stems only 2 or 3 inches apart. It was hoped that experiments which were in progress would afford evidence as to the effect of various manures on both the diseases, but owing to the general arrest of the outbreak which came about with the advent of dry sunny weather, this was not obtained. It does not seem likely that food supply has much influence, on curly-leaf at any rate. It was abundant on land which had been too heavily manured, so that the cotton plants

were of very rank growth, and on land which had grown cotton for seven years without manure. The one suggestion which does seem so far to hold good with regard to loggerhead is that the abnormality is in some way connected with very early or out of-season planting, the apparent influence of which will be indicated in the section dealing with the history of the occurrence of the disease.

Neither form is connected with seed of any particular origin. Leaf-curl has occurred in strains developed in St. Kitts and Nevis, in an imported Barbados strain (Stirling), and in a strain of very high-grade cotton received from an extra-West-Indian source. Loggerhead occurred in 1914 in various St. Kitts and Nevis strains, and in plants from seed newly imported from St. Vincent and from Barbados.

HISTORY.*

LOGGERHEAD. Attention seems to have been first called to the loggerhead affection in 1910, in which year it appeared to an alarming extent on an estate situated towards the western extremity of the island. Then, as now, it was not regular or universal in any field The seed was from the St. Kitts Experiment Station at La Guérite. It has since been noticed to some extent in the same district every year In 1913 it was severe on two estates 2 or 3 miles to the north-west Again the cotton happened to be from La Guerite seed, and in consequence a change was made in 1914 and seed of the Stirling (Barbados) strain, grown three years in St. Kitts, was used. Early plantings from this seed were so badly affected that a fairly large area was cleared, about June, and replanted.

In the neighbourhood of Basseterre, sporadic examples have occurred each year since the affection was recognized, and have been usually rogued out. In July 1914 the affection appeared to a much greater extent, but still with a scattered distribution, in various fields situated on the La Guérite lands. This cotton was planted, owing to the occurrence of early rains, some two months earlier than is customary.

In Nevis, though curly-leaf has been common on some areas since 1911, the loggerhead affection has only occurred sporadically, and has not been regarded as of serious importance. At the time of my visit it was somewhat more common, and in two or three places had seriously affected small areas. One of these was a plot at the Experiment Station planted with St. Vincent seed.

CURLY-LEAF. In St. Kitts the first noticeable occurrence of curly-leaf was in 1911, in a field of rich land on an estate on the windward side of the island. The Agricultural Superintendent is not aware of its occurrence there since. A plot at the La Guérite Station planted in December 1912 was seriously affected in February 1913, and gave a negligible yield. It is notable that no loggerhead plants were seen in this plot. At the same

*For information under this head I am largely indebted to Mr. F. R. Shepherd, Agricultural Superintendent in St. Kitts-Nevis, and to Mr. W. I. Howell, Agricultural Instructor in Nevis.

CURLY-LEAF COTTON.
PLANT VIEWED FROM ABOVE.

CURLY-LEAF COTTON.

station a high-grade cotton from imported seed, planted in August 1913, showed a tendency to curly-leaf, but the bearing was not much affected. In 1914 the cotton in a sheltered field just on the outskirts of Basseterre developed curly-leaf very rapidly during rainy weather in July, and a fair amount of the loggerhead affection was also present. This field has grown cotton seven years without manure. In the same neighbourhood, at the same time, another field in a much more exposed position, planted with seed from a different source, also showed a mixture of the two forms.

In Nevis curly-leaf has been more widespread, and has been more serious in its effects than in St. Kitts. It was first noticed as common in 1911, on an estate on the elevated lands on the eastern side of the island, where it was again prevalent in 1912. In 1913 it occurred there to a much smaller extent, and did not prevent the yield, as a whole, from being good. The season was a drier one. In 1914 it was again severe in the same locality, making its appearance in May. During June it was observed in quantity at two other places, and was noticed to some extent in plots here and there. It appeared earlier in this year, in which the rainfall was abnormal; in 1913 it was not noticed before September, but was then more common in certain places than it had become at the time of my visit.

I am informed by Mr. W. Robson, Curator of the Botanic Station in Montserrat, that curly-leaf is known to have occurred occasionally in that island, where it goes by the name of 'chibble leaf'.

CURLY-LEAF IN ST. CROIX.

Brief announcements have been made since 1911 (Smith 1913, 1914) of the occurrence in the island of St. Croix (Danish West Indies) of a troublesome disease of cotton, which is evidently closely related to curly-leaf. Dr. Longfield Smith, Director of Agriculture in that island, has kindly forwarded unpublished information which enables a comparison to be made.

CHARACTERS. After reading my report on the St. Kitts-Nevis affection and examining photographs, Dr. Smith states that the disease in St. Croix appears to be the same as the curly-leaf there described, but with differences in the degree to which the characteristic symptoms are developed. Thus the leaves do not exhibit to the same extent the curly margin, but the occurrence of small irregular holes, beginning in the very young leaves as brown spots, is so abundant as to make this the most prominent feature of the disease. From the examination of specimens forwarded by Dr. Smith I am able to say that these injuries have exactly the same appearance as those mentioned above as occurring in the St. Kitts plants, in none of which, however, was the damage anything so severe. The yellowing of the leaves along the veins, which was seen in some cases in St. Kitts, has not been observed in St. Croix. The blackening and loss of the rudimentary flower buds and the pink discoloration of the corolla in older buds are marked symptoms of the St. Croix as of the St. Kitts form of the disease. The consequent loss of crop experienced in St. Croix has on occasion reduced the

yield per acre to less than 100 lb. of seed-cotton, in places where at least 1,000 lb. might otherwise have been expected.

CONDITIONS OF OCCURRENCE. A feature noticed in St. Croix with regard to the distribution of the disease is that plants forming the outside rows of a field are often healthy, while those within are all affected Apart from this, no mixture of healthy and diseased plants has been observed. The disease is always associated with vigorous growth in the first two months after planting, and is especially prevalent on the eastern side of the island, where the soil is deep. Cotton planted on new land is generally worst affected. On a certain estate, where in 1912 heavy and continuous rains occurred soon after planting, the growth was luxuriant, but as soon as the flowers began to form, curly-leaf set in, and the majority of the fields yielded very poorly. One field, however, was badly drained, and the water lodged for days among the cotton plants, stunting them so much that the manager was minded to pull them up. This field developed very little curly-leaf, and eventually gave an excellent yield.

The loggerhead affection appears not to have been met with in St Croix.

Relationship of Curly-leaf and Loggerhead.

In form, as has been shown, the two affections are typically quite distinct. They have in common the production of a discoloration of the leaves, but the form which this discoloration takes is usually, though not always, distinctive Both have an effect on the length attained by the internodes, but in opposite directions. The effect on the buds and on the flowers is the same, but it is possible that this represents throughout, as in the case of the very young buds, a reaction of the plant not specifically connected with either affection. There is an appearance of a transition between the two forms, but only because each extreme is connected by a series of intermediate forms to the normal. In occurrence, as has been shown, they may be, and commonly are, quite separate.

There is thus no evidence of a connexion between the two forms, except such as may be inferred from their apparent association with similar conditions, and the similarity of their nature as physiological affections of the same organs of the plant.

Abnormal Growth in Hybrid Cottons.

Experiments have from time to time been carried on in some of the West Indian islands in the raising of hybrids between Sea Island and the local perennial forms of *Gossypium barbadense*, L.

Experience goes to show that if care is taken to work with pure types, the first hybrid generation is uniform and has highly desirable characters. If, however, the progeny of these plants is grown, or if the 'native' parent in the first instance was impure, a bewildering variety of forms is encountered. One of the most common abnormalities met with has a strong resemblance to the loggerhead form described above. The internodes are very much shortened, so that the plant has

LOGGER-HEAD COTTON.

LOGGER-HEAD COTTON.

a dwarfed and very bushy appearance; the leaves are always mottled, the mixture being one of dark and of yellowish greens. In addition to these characters, which this form shares with loggerhead, the stems up to the youngest internodes exhibit a precocious cork formation of a very scaly nature, which extends even along the petioles. Bearing does not seem to be affected. Such plants are occasionally met with in Sea Island fields in Barbados, where I have regarded them as due to accidental hybridization.

Dr. Smith informs me that this condition is normal for the hybrids he has raised between Sea Island and the St. Croix 'native' cotton, and that the plants appear quite healthy, and mature an enormous number of bolls. Plants of the form under discussion have also occurred in hybrids grown in the Experiment Stations at St. Kitts and Nevis At the latter station in 1913, some 20 per cent. or more appeared. In Barbados, plants of what may be regarded as the opposite type, in which the shoots grow out to an abnormal length, so that the lower branches run along the ground, are sometimes met with in hybrids of the second and subsequent generations.

In addition to its intrinsic interest, the fact of the existence of hybrids approximating closely in form to loggerhead plants has importance because of the liability to confusion between the two, but quite apart from the differences indicated, it is impossible to consider the occurrence of loggerhead in the Sea Island fields in St. Kitts and Nevis as due to hybridization. I have myself seen a case where a few weeks' difference in the time of planting from the same lot of seed had been followed by the abundant development of loggerhead plants in the one field, and their absence from the next; and such an effect following a difference in time or place of planting seems to be a common experience.

Whether the abnormal form of these hybrids is a direct and necessary consequence of the constitution of their zygotes, or is produced, as in the case of the loggerhead Sea Island plants, by lack of adjustment in certain circumstances to their environment, is a question as to which I have not sufficient evidence to form an opinion. A fact which seems to favour the latter hypothesis, is that the development of the abnormal characters is not always constant throughout the life of the individual plant.

COMPARISON WITH SIMILAR AFFECTIONS.

There is a fairly well marked class of diseases having the same general nature as the St. Kitts-Nevis affections. They appear on a wide range of plants, and each has its individual characteristics, according to the nature of the plant attacked. They have in common an apparently similar physiological origin and the exhibition of outward symptoms involving malformation and discoloration of the leaves, and in several there is a tendency to interference with the normal development of the vascular tissue. To this class have been assigned, definitely or tentatively, as the case may be, the mosaic diseases of tobacco, tomato, potato, and melon, 'sereh' of sugar-cane, leaf roll and 'curly dwarf' of potato, 'yellows' and 'rosette' of peach, leaf-curl of cassava (Zimmermann, 1906), and of mulberry (Suzuki, 1902), and

'roncet' of grape vine. Several of these diseases have been made the subject of long and elaborate investigations by many different workers—the literature of potato leaf-curl, for example, would if collected fill volumes; but beyond a fairly general agreement among biochemical investigators that their symptoms are due to some disturbance of the normal distribution and activities of the enzymes on which the internal functions of the plant depend, their nature is unknown.

It is a peculiar feature of some of them, that although they are not due to the action of any recognizable parasitic organism, and do not follow the general lines of diseases so induced, they have yet been conclusively proved to be communicable by contagion—a fact which has led some investigators to assume the presence in such a disease of a virus capable of propagating itself within the tissues of the host.

In the case of some of the plants concerned, it has been shown that the diseased condition may be artificially induced by a violent interference with normal growth such as is produced by the cutting back of a plant in an active vegetative condition.

In certain of these diseases, sucking insects of the order Hemiptera are regarded as playing a part, but as to whether they originate the affections, convey them, or merely bring out certain symptoms in plants already in an abnormal condition, the evidence varies in different cases, and does not appear to permit of a general statement.

COTTON. O. F. Cook (1913) has described under the name of leaf-cut or tomosis, a physiological affection of cotton, occurring in the United States, which produces a condition closely resembling one of the symptoms of curly-leaf, in that the leaves of seedlings or young plants as they expand are found to be crumpled, perforated with irregular holes, and frayed at the edges. Their terminal buds are very liable to be aborted. Plants have occasionally retained the affection throughout their existence, but this has been seen only in such plants as were abnormal in other ways, being regarded as hybrids or mutations. Climatic factors, particularly the effects of bright sunshine after a cold night, are held to be responsible for the injury. Plants are less liable to damage if growing in shady or moist places, or planted close together—conditions which are exactly those inducing curly-leaf in the West Indies. It does not seem probable that there is any real relation between the two.

The mosaic disease of cotton (Atkinson, 1892), as known in the United States, so far as it has been investigated appears to have little in common with the St. Kitts and Nevis affections. No interference with the form of the leaves is described in connexion with it, and it is regarded as associated with water shortage in light soils.

In German East Africa a serious cotton trouble exists in the form of a leaf-curling or 'leaf-frizzling' disease (Kräuselkrankheit). Certain observers (Vosseler, 1905, Reiter, 1911), regard the disease as purely physiological in its nature, and as due to too early planting, and consequent exposure to heavy rainfall. Kränzlin (1911) has shown a connexion in certain circumstances

between the disease and a Jassid leaf-hopper (*Chlorita facialis*, Jac.), but leaves it an open question whether the insect is the originating or only the exciting cause of the disease. In an earlier paper he took the view that too rapid growth is to be regarded as the predisposing cause. Thiele (1913) describes the occurrence of typical Kräuselkrankheit on cotton grown in a hot-house in Germany, where the exciting cause was 'red spider' (*Tetranychus*). Morstatt (1911) states that in East Africa, Chlorita may be very abundant without the symptoms of the disease appearing, while, on the other hand, the disease may occur when the insect is so uncommon as to preclude the idea of its responsibility.

OTHER PLANTS. Some points of resemblance to the last mentioned disease are afforded by the curly-top malady of sugar-beet in the United States, the chemical side of which has been more thoroughly investigated. It is characterized by an inward curling of the leaves, a distortion of the veins of the affected leaves, hairy roots, and checked growth. Flowering stems, when formed at all, are stunted, and few of the plants possess sufficient vitality to produce seed (Shaw, 1910). Bunzel (1912-13) has shown that the curly leaves contain two to three times the amount of oxidase present in normal leaves. Shaw regards the attacks of a Jassid leaf hopper (*Eutettix*) as the primary cause of the trouble, but points out that it is not a case of simple injury but is comparable with the condition of carnations to which Woods (1900) applied the term stigmonose, in which a physiological disturbance involving a marked increase in oxidizing enzymes persists after the exciting cause, in this case aphides, has been removed. Woods made the very significant observation that weak plants, rich in oxidizing enzymes, react more strongly to insect punctures, and that aphides are especially fond of such plants and increase rapidly upon them.

The mosaic disease, or mottled top, of tobacco is described by Woods (1902) as producing a more or less sharply defined differentiation of the colour of the leaves into light and dark green areas, arranged between the larger vascular bundles, or in some cases occurring indiscriminately. It is capable of causing severe distortion of the leaf, and the whole plant may become so deformed as to be almost unrecognizable.

There is no evidence that plants from diseased parents are subject to the disease more than those from healthy ones. The disease is not due to parasites of any kind, but according to Woods, is 'the result of defective nutrition of the young dividing and rapidly growing cells, due to a lack of elaborated nitrogenous reserve food, accompanied by an abnormal increase in activity of oxidizing enzyme, in the diseased cells.'

The poverty in reserve nitrogen may be attributed to the retarding action of the oxydase on the normal fermentation processes. On the decay of the plant the oxydase is liberated and remains active in the soil. It appears to be readily absorbed by young plants, and originates the disease in them. The danger of this is small in the field, but much greater in the seed bed. Rapid growth is very favourable to the disease.

Sturgis (quoted by Woods) says that it seems probable that the disease is purely a physiological one, caused primarily by sudden changes, or atmospheric conditions, which disturb the normal balance between evaporation of water from the leaves and its absorption by the roots, and secondarily by soil conditions which prevent the speedy restoration of that balance.

The mosaic diseases of tomato (Melchers, 1913), potato and related plants appear to be identical or closely similar in their nature to that of tobacco.

With regard to the leaf-roll of potato, Sorauer made the suggestion that the disease is a consequence of the disturbance of the balance of enzymes, principally brought about by the effects of abnormal weather. Doby (1911) has confirmed this hypothesis by a series of biochemical researches, in which he found a low reserve nitrogen and starch content, and a high concentration of oxydase to be characteristic of the unhealthy tubers.

Doby cites the opinion of Pozzi-Escott, that the action of the oxydases is to destroy the normal enzymes, especially those concerned in the process of assimilation, and also cites the conclusion of Spieckermann that translocation of materials is hindered.

There exist on the vine and on the common potato two diseases which in their outward symptoms are closely parallel with the loggerhead affection of cotton.

The vine disease 'roncet' or 'court-noue' (Pantanelli, 1912) occurs in many or all the wine-producing countries of Europe. It is characterized by a strongly marked shortening of the internodes, a mottled (mosaic) condition of the leaves, and an atrophy or malformation of the inflorescences The general appearance produced is strikingly like that of a loggerhead cotton plant. A further parallel is to be seen in the ability of shoots whose growth has been abnormal in Spring to resume their proper growth later in the year, following this in some cases by a return to abnormality in Autumn.

Pantanelli found a striking deficiency in nitrogenous reserve materials and a large increase in oxydases. The intensity of respiration is two to three times increased. He goes back for the first cause of the disease to root disturbances produced in soils that are rendered 'vine-sick' by the products of decay of the vine roots accumulated in the soil during long-continued cultivation of the same crop. He failed to obtain infection by contact or by inoculation of sap.

The potato disease referred to is one recently described from America (Orton, 1914) under the name of 'curly dwarf', and known also in Germany. The stem and its branches, the petioles, and even the midribs and veins of the leaves all tend to be shortened, in many cases to a marked extent, so that the foliage is thickly clustered. The diminished growth of the leaf veins in proportion to the parenchyma results in a wrinkled leaf often strongly curled downward. The colour of the foliage in severe cases is light green or yellow.

The nature and cause of the disease remain unknown, but no evidence of parasites has been found. It has been proved that the disease is transmitted when tubers from affected plants are

used as 'seed'. It is regarded as a sign of permanent deterioration in the stock in which it appears.

The leaf-curl of mulberry has been made the subject of chemical investigation by Suzuki (1902). It is an affection outwardly marked by deformation of the leaves and retarded growth, and has been disastrous in its results in Japan. Plants heavily manured are most susceptible, those in poor soils or unmanured escape. The first cause of the disease in nearly all cases is hard pruning.

The diseased leaves show a marked poverty in nitrogenous compounds, and an abnormal development of oxydases. The development of the fibrous elements is considerably delayed. The translocation of materials is hindered, and starch accumulates in the leaves, either owing to the incomplete development of the conducting system, or to the interference of the oxydases with diastatic and proteolytic activity. Suzuki regards a diminution of the absorptive power of the roots as the beginning of this chain of events.

It will be seen that where chemical evidence is available, and according to the investigators cited, there is a fairly general agreement in the chemical as in the external symptoms of the diseases brought into this comparison, and while in the absence of a biochemical investigation there is only analogy to proceed upon, it appears very probable that the affections of cotton under consideration are of the same nature.

The possibility of a clear conception of what takes place awaits the further advance of our general knowledge of plant chemistry and physiology.

Conclusions.

The curly-leaf and loggerhead affections are to be classed with what are commonly termed physiological diseases. Their actual nature is unknown. They can occur quite separately, and there is no clear evidence of a connexion between them.

The curly-leaf disease appears to be definitely connected with rapid growth, brought about under certain soil conditions including depth and easy permeability when plants in the active vegetative stage receive an abundant supply of water, and the checks to growth ordinarily exercised by sun and wind are removed by the prevalence of cloudy weather, the shading of the situation, or the crowding of the plants themselves. It disappears when these conditions are changed.

The loggerhead disease is very erratic in its occurrence, and its dependence on weather is not so clear. It is however characteristic as a rule of certain districts, and has appeared in others only when the weather has been abnormal, or the time of planting has been changed.

Both diseases are known to have occurred for several years, and there is no indication of any cumulative increase. Their incidence in any year is strictly local in time and place, and in St. Kitts and Nevis, cases of severe damage are few in number, and of small proportions. There appears to be no ground for apprehension that they will increase in amount.

There is strong evidence against the connexion of either disease with any particular strain or strains of seed.

No remedial measures are considered possible. In localities which by reason of their soil conditions are subject to the diseases, careful regard should be had to the expectation of rain in fixing the time of planting, and crowding of the plants should be avoided.

REFERENCES.

Atkinson, G. F. 1892: Some diseases of Cotton. *Agricultural Experiment Station. Alabama, Bull. 41.*

Balls, W. L. 1912: *The Cotton Plant in Egypt.*

Bunzel, H. H. 1912: The measurement of the oxidase content of plant juices. *U.S. Dept. Agri. Bur. Pl. Ind. Bull. 238.*

1913: A Biochemical Study of the Curly-top of Sugar-beets. *U.S. Dept. Agr. Bur. Pl. Ind. Bull. 277.*

Cook, O. F. 1913: Leaf-cut or Tomosis, a Disorder of Cotton seedlings. *U.S. Dept. Agri. Bur. Pl. Ind. Circ. 120*, pp. 29-34.

Doby, G. 1911: Biochemische Untersuchungen über die Blattrollkrankheit der Kartoffel. *Zeitsch. f. Pflanzenkr.* XXI. 10-17. 321-36; XXII. 204-11. 401-3.

Kränzlin, 1911: Beitrage zur Kenntnis der Krauselkrankheit der Baumwolle. *Der Pflanzer*, VII, 327-29.

Melchers, L. E. 1913: The Mosaic Disease of the Tomato and related plants. *Ohio Naturalist*, XIII, 149-75; reviews the position with regard to mosaic diseases and gives an extensive bibliography.

Morstatt, H. 1914: Die Schädlinge der Baumwolle in Deutsch Ostafrica. *Beiheft zum Pflanzer Nr. I. Jahrgang X.*

Nowell, W. 1914: Diseases of the Cotton Plant in the West Indies. *Imp. Dept. of Agric. for W. I., Pamphlet 74*: pp. 105-9.

Orton, W. A. 1914: Potato Wilt, Leaf-roll and related diseases. *U.S. Dept. Agric. Bur. Pl. Ind. Bull. 64.*

Pantanelli, E. 1912: Beiträge zur Kenntnis der Roncetkrankheit oder Krautern der Rebe. *Zeitsch. f. Pflanzenkr.* XXII, 1-38, XXIII, 1-34.

Reiter, H. 1911: Die Baumwolle am Rufivi *Der Pflanzer*, VII, 194-202.

Shaw, H.B. 1910: The Curly-top of Beets. *U.S Dept. Agric. Bur. Pl. Ind. Bull. 181.*

Smith, L. 1913: Report of the Agricultural Experiment Station in St. Croix, 1911-12.

1914: do. 1912-13.

Suzuki, U. 1902: Chemische und physiologische Studien über die Schrumpf-Krankheit des Maulbeerbaumes. *Zeitsch. f. Pflanzenkr.* XII, 203-26, 258-78.

Thiele, R. 1913: Ein Fall typischer Kräuselkrankheit bei Baumwolle ins Gewächshaus. *Zeitsch. f. Pflanzenkr.* XXIII, 198-201.

Townsend, C.O. 1908: Curly top, a Disease of the Sugar-beet. *U.S. Dept. Agr. Bur. Pl. Ind. Bull. 122.*

Vosseler 1905: *Der Pflanzer*, 1905, p. 287 (not seen) cited by Detmann, *Zeitsch. f. Pflanzenkr.* XVII, 246.

Woods, A. F., 1900: Stigmonose, a disease of Carnations and other Pinks. *U. S Dept. Agr. Divn. of Veg. Phys. and Path. Bull. 19.*

1902: The Mosaic Disease of Tobacco. *U. S. Dept. Agric. Bur. Pl. Ind. Bull. 18.*

Zimmermann 1906: Der Pflanzer II. 182 (not seen); review in *Zeitsch. f. Pflanzenkr*, XVII, 217.

NOTE.

In the *Journal of Agricultural Research*, Vol. 2, No. 5, pp. 373-404 (August 19 4) which came to hand after this paper was in type. Bunzel gives the results of an investigation of the amount of oxidases in healthy and in curly dwarf potatoes. He found a greater oxidase activity in the latter, both in the juice of their tubers and of their foliage. It appears likely that the respiration of the diseased plants is intensified, so that they are in a condition corresponding to 'fever' in animals. Pantanelli (1912) found that in vine shoots with roncet disease respiration was increased two to three times, and this was accompanied by a noticeable rise in the temperature.

W. N.

[Pages 221 to 317, issued March 22, 1915.]

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INDEX.

NOTE.—In the preparation of this index, certain general headings have been introduced, which, in order to facilitate reference, may be enumerated, as follows:—Animal Parasites, Authors, Diseases of Plants and Insects, and Insect Pests.

A.

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W.

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